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[MHD 11: Anaesthetic, Resuscitation and Allied Equipment]

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Indian Standard

NON-FLAMMABLE MEDICAL GAS PIPELINE SYSTEMS

भारतीय मानक

अज्वलनशील चिकित्सा गैस पाईप लाईन तंत्र

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Indian Standard

NON-FLAMMABLE MEDICAL GAS PIPELINE SYSTEMS

NATIONAL FOREWORD

This Indian Standard, which is identical with ISO 7396 : 1987 'Non-flammable medical gas pipeline systems', issued by the International Organization for Standardization (ISO), was adopted by the Bureau of Indian Standards on 16 June 1989 on the recommendation of the Anaesthetic Resuscitation and Allied Equipments Sectional Committee (MHD 13) and approval of the Medical Equipment and Hospital Planning Division Council.

The text of ISO standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

CROSS REFERENCES

In this Indian Standard, the following International Standards are referred to. Read in their respective places the following:

International Standard	*Indian Standard*	*Degree of Correspondence*
ISO 65 : 1981 Carbon steel tubes suitable for screwing in accordance with ISO 7/1	IS 1239 (Part 1) : 1979 Mild steel tubes, tubulars and other wrought steel fittings: Part 1 Mild steel tubes (*fourth revision*)	Technically equivalent
IEC 364 : Electrical Installations of buildings	SP 30 : 1984 National electrical code	Technically equivalent
IEC 601-1 Medical electrical equipment — Part 1 : General requirements	IS 8607 (Part 1) : 1977 General and safety requirements for electrical equipment used in medical practice: Part 1 General	Technically equivalent

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following ISO standards and has decided that they are acceptable for use in conjunction with this standard:

ISO 32 Gas cylinders for medical use — Marking for identification of content

ISO 274 Copper tubes of circular section — Dimensions

ISO 407 Small medical gas cylinders — Yoke type valve connections

ISO 5145 Cylinder valve outlets for gases and gas mixtures — Selection and dimensions (at present at the draft stage)

ISO 5359 Low-pressure flexible connecting assemblies (hose assemblies) for use with medical gas systems (at present at the draft stage)

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0 Introduction

In medical gas pipeline systems it is vital that high safety standards are maintained and that there is no risk of failure of supply or plant without adequate warning. To ensure this, particular consideration has been given to the following:

a) design of equipment to ensure non-interchangeability between services;

b) use of correct materials, and cleanliness of materials;

c) correct installation;

d) provision of reserve supplies of gas, and reserve plant;

e) warning systems;

f) testing and commissioning to ensure that pipelines are not cross-connected;

g) identification of pipelines.

NOTE — Components of the non-flammable medical gas system (hereinafter referred to as the "pipeline system") should be installed by a manufacturer(s) or under the supervision of a manufacturer(s) or person(s) familiar with the correct practices for construction, installation and use.

In many countries, there are national standards, regulations or legal requirements dealing with one or more matters referred to in this International Standard, for example building, fire and electrical regulations. These often vary in their details and it is recognized that these may have to take precedence over the requirements of this International Standard.

It is impossible to overstress the importance of maintenance in ensuring that a medical gas pipeline system continues to perform to the requirements of this International Standard. For this reason, the installer of a system is required to provide drawings and maintenance schedules to the owner or user of the system (see 11.5) and it is the responsibility of the owner or user to ensure that proper maintenance is carried out under an effective method of control. Annex D gives recommendations for the organization of a maintenance operation. Annex F gives recommendations for emergency procedures.

When the installer retains ownership of parts of the gas supply system, he is responsible for their maintenance.

Medical gases, particularly oxygen, require knowledge of their characteristics and hazards, and the precautions to take regarding their care, handling, distribution and control. Reference should be made to national codes and regulations and/or an appropriate authority for such information.

The scope of this International Standard does not include the provision for gas-specific connectors for cryogenic storage vessels and transport vehicles, nor for the inlet/outlet connectors or portable liquid, cryogenic or gas cylinders. Such gas-specific connectors, however, are essential to ensure that only the correct gas can be used for the gas supply to a patient. The user of this International Standard should ensure that the supplier of the gas is using such gas-specific connectors.

NOTE — Terminal units have a range of non-interchangeable screwed and quick-connect connectors which are specified in ISO 5359. These are intended for use, for example, as inlet connectors to a continuous flow anaesthetic machine and other medical devices (see also ISO 407 and ISO 5145).

1 Scope and field of application

1.1 This International Standard specifies minimum requirements for the installation, construction, function, documentation and testing of non-flammable medical gas pipeline systems to ensure patient safety by delivery of the correct gas from the pipeline system. It includes requirements for the source of supply, distribution system, terminal units, warning systems, and for non-interchangeability between key components and service outlets.

1.2 It applies only to pipeline systems for the following non-flammable medical gases:

a) oxygen;

b) nitrous oxide;

c) medical air;

d) nitrogen;

e) helium[1];

f) carbon dioxide;

g) specified mixtures of the gases listed in a) to f);

h) medical vacuum.

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[1] Special consideration should be given to material and installation for helium services.

1.3 It applies to pipeline systems used at pressures required for patient care, including therapeutic, diagnostic and prophylactic applications and surgical tool applications. Pipeline systems used for non-clinical purposes are excluded. A medical air pipeline, supplied from an air compressor system only, may be extended to applications not directly related to patient care and certain precautions are given in annex G, for applications such as

a) the operation of ceiling columns in theatres;

b) anaesthetic waste gas systems;

c) sterilizer departments;

d) breathing air for surgical personnel;

e) pneumatic control of air conditioning;

f) testing of medical equipment.

Extensions are not permitted for applications such as

a) general workshop use;

b) motor repair workshops;

c) spray painting;

d) tyre inflation;

e) those which may impose unforeseen demands, which could prejudice the availability and/or quality of medical air for normal patient care purposes;

f) reservoirs for pressurization of hydraulic fluids.

2 References

ISO 32, *Gas cylinders for medical use — Marking for identification of content.*

ISO 65, *Carbon steel tubes suitable for screwing in accordance with ISO 7/1.*

ISO 274, *Copper tubes of circular section — Dimensions.*

ISO 407, *Small medical gas cylinders — Yoke-type valve connections.*

ISO 5145, *Cylinder valve outlets for gases and gas mixtures — Selection and dimensioning.* [1].

ISO 5359, *Low-pressure flexible connecting assemblies (hose assemblies) for use with medical gas systems.* [1]

IEC Publication 364, *Electrical installations of buildings.*

IEC Publication 601-1, *Medical electrical equipment — Part 1: General requirements.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 (non-flammable medical gas) pipeline system: The complete system which comprises a central supply system with control equipment, a pipeline distribution system and terminal units at the points where non-flammable medical gases may be delivered (see figure 1).

3.2 central supply system: A source of medical gas comprising one or more of the following items of plant:

a) a system of gas cylinders (see figures 6 and 12);

b) cryogenic or non-cryogenic liquid supply (see figures 7, 8 and 12);

c) air compressors (see figures 9 and 12);

d) proportioning equipment (see figures 11 and 12);

e) medical oxygen concentrators;

f) vacuum pumps (see figure 10);

3.3 primary supply: That portion of the central supply system which supplies the pipeline distribution system.

3.4 secondary supply: That portion of the central supply system which automatically supplies the pipeline distribution system when the primary supply becomes exhausted or fails and then becomes the primary supply.

3.5 reserve supply: That portion of the central supply system, activated manually or automatically, which supplies the pipeline distribution system in the event of failure of the primary and secondary supplies.

3.6 cryogenic liquid system: Liquid oxygen or liquid nitrogen central supply system which consists of a primary supply with either a secondary supply, a reserve supply or both (see figures 7, 8 and 12).

NOTE — Liquefied nitrous oxide and carbon dioxide are not cryogenic.

3.7 non-cryogenic liquid system: Supply system of nitrous oxide and carbon dioxide with reserve supply.

3.8 source of supply: Central supply system with associated control equipment and that portion of the pipeline up to and including the main pipeline shut-off valve.

3.9 air compressor system: System which comprises two or more air compressors designed to provide clean, dry, oil-free air to a pipeline distribution system at a constant pressure through its control equipment (see figures 9 and 12) which should include a reserve supply.

3.10 vacuum system: A system which comprises two o more vacuum pumps designed to provide a vacuum (see figure 10).

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[1] At present at the stage of draft.

3.11 proportioning equipment: Central supply system in which gases can be mixed in specified ratios (see figures 11 and 12).

3.12 medical oxygen concentrator (for example a pressure swing adsorber): System comprising compressor(s), nitrogen adsorber unit(s) and reservoir by means of which oxygen-enriched, clean, dry, oil-free air is generated from atmospheric air.

3.13 control equipment: Those items necessary to maintain the gas supply at a set pressure within the pipeline distribution system, such as pressure-control regulators, relief valves, alarm initiators, and manual and automatic valves.

3.14 pipeline distribution system: That part of a pipeline system linking the source of supply to the terminal units, including any necessary branch isolation valves and any additional line pressure regulators required (see figures 1 and 12).

3.15 terminal unit: An outlet assembly (inlet for vacuum) in a piped medical gas distribution system at which the user makes connections and disconnections (see figure 4).

3.16 terminal unit check valve: A valve which remains closed until opened by insertion of an appropriate probe and which then permits flow in both directions.

3.17 terminal unit maintenance valve: A valve within the terminal unit assembly which permits maintenance of the terminal unit without shutting down the pipeline system to other terminal units.

3.18 terminal unit base block: That part of a terminal unit which is permanently attached to the pipeline distribution system, or attached to a connecting assembly.

3.19 gas-specific connection point (socket assembly): That part of a terminal unit which is the receptor for a non-interchangeable gas-specific connecting assembly and which is attached to the base block by the appropriate non-interchangeable gas-specific device.

3.20 shut-off valve; isolating valve: A manual or automatic valve which prevents flow in both directions when closed.

3.21 non-return valve: A valve which permits flow in one direction only.

3.22 low-pressure flexible connecting assembly: A hose, tube or pipe with permanently attached gas-specific connectors, which is normally designed to conduct a medical gas at its nominal operating pressure (see ISO 5359).

3.23 gas-specific connectors: Connectors which are either NIST (non-interchangeable screw-threaded) or DISS (diameter-indexed safety system), or non-interchangeable quick connectors.

3.24 pressure-safety valve: A valve to limit the pipeline pressure downstream of line pressure regulators.

3.25 pressure-relief valve: A valve to limit pressure downstream of any operating pressure regulator.

3.26 operating alarm: Visual, or visual and auditory, alarm to indicate the necessity for technical staff to adjust the supply or to correct a malfunction.

3.27 emergency alarm: Visual and auditory alarm to indicate to technical and medical staff that the supply is outside normal operating limits

3.28 nominal operating pressure: The normal pressure at which pipeline distribution systems are designed to operate.

3.29 system design flow capacity: Flow capacity calculated from the maximum flow requirements of the health care facility corrected by operational diversity factor.

4 Materials

NOTE – Special consideration should be given to materials and installation for helium services.

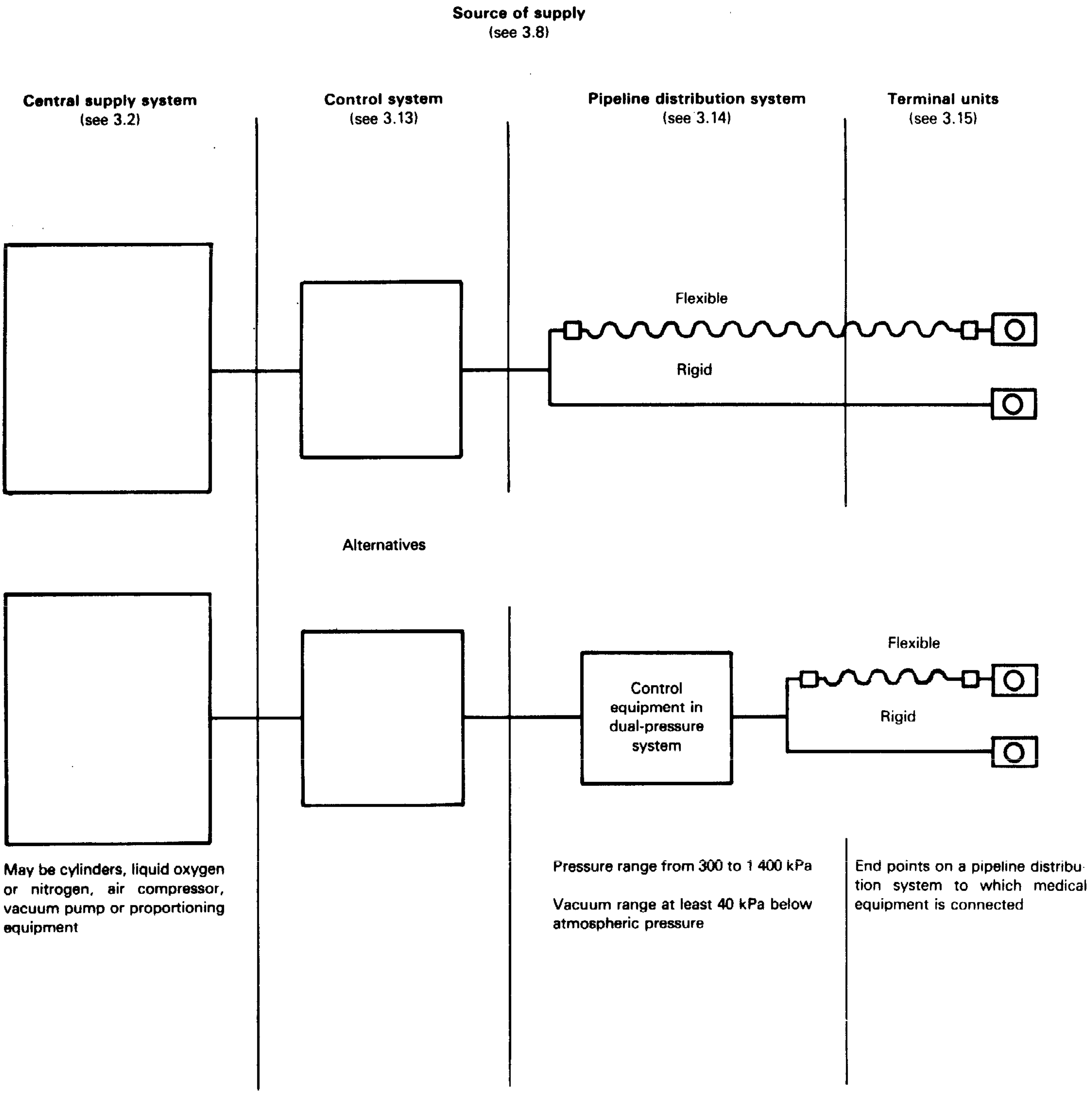
4.1 Compatibility with oxygen

4.1.1 Except for vacuum systems, the components of a pipeline system for medical gases shall be compatible with oxygen under all conditions and shall be clean and free from oil, grease and particulate matter.

NOTE – The anti-corrosion properties of all components against oxygen, moisture and surrounding materials should be considered. Compatibility involves both combustibility and ease of ignition. Materials which burn in air will burn violently in pure oxygen. Many materials which do not burn in air will do so in pure oxygen, particularly under pressure. Similarly, materials which can be ignited in air require lower ignition energies in oxygen. Many such materials may be ignited by friction at a valve seat or stem packing by adiabatic compression produced when oxygen at high pressure is rapidly introduced into a system initially at low pressure.

No relaxation of the requirement in 4.1.1 is permitted for any gas because of the difficulties of segregation of materials in stores and particularly on hospital sites during installation.

For vacuum systems, a wider selection of materials is possible, for example plastics, and in this case the provision for compatibility with oxygen need not apply.


Source of supply
(see 3.8)
Central supply system
(see 3.2)
Control system
(see 3.13)
Pipeline distribution system
(see 3.14)
Terminal units
(see 3.15)
Flexible
Rigid
Alternatives
Control equipment in dual-pressure system
Flexible
Rigid
May be cylinders, liquid oxygen or nitrogen, air compressor, vacuum pump or proportioning equipment
Pressure range from 300 to 1 400 kPa
Vacuum range at least 40 kPa below atmospheric pressure
End points on a pipeline distribution system to which medical equipment is connected

NOTE — It is possible to have more than one pipeline pressure in the distribution system of a medical gas supply.

Figure 1 — Typical general layout of a non-flammable medical gas pipeline system

4.1.2 Components as specified in 4.1.1 shall include, but not be limited to, containers, pipes, valve seats, lubricants, fittings and gaskets.

4.1.3 Pipelines shall be made of materials given in annex A or appropriate equivalents.

4.2 Cleaning

All pipes, valves and fittings shall be cleaned and degreased before installation.

NOTE — These items should be supplied clean and degreased.

All precautions shall then be taken to maintain cleanliness during transportation, storage and installation.

5 Source of supply

5.1 General requirements

5.1.1 The design of the storage capacity of any source of supply system and its reserve shall be based on the estimated usage and the frequency of delivery by the gas supplier.

5.1.2 The source of supply may consist of one or more of the following:

a) gas in manifolded portable cylinders;

b) gas in manifolded cylinders on a trailer or pallet;

c) cryogenic liquid in portable cylinders (sometimes manifolded);

d) cryogenic liquid in manifolded cylinders on a trailer;

e) cryogenic liquid in a stationary vessel(s);

f) liquefied gas in a vessel;

g) a medical air-compressing system;

h) a medical vacuum-pumping system;

i) a proportioning system;

j) a medical oxygen concentrator.

5.1.3 The following provision for failure of supply shall be made.

In a cryogenic liquid oxygen system, an inlet to the system for connecting a temporary source for emergency/maintenance situations shall be incorporated in a convenient location. The inlet shall be physically protected to prevent tampering and unauthorized access. It shall have a gas-specific inlet. This connection shall be suitably controlled with the necessary valves to allow standby or emergency supply of medical gas and isolation of the normal source of supply. The emergency source shall incorporate a pressure regulator and safety-relief device which may or may not be a permanent part of the inlet to the system.

NOTES

1 If the reserve supply is housed separately and the normal source of supply isolated, this inlet may not be necessary.

2 For all other systems except vacuum, an alternative emergency inlet point may be provided. Any such connector should be gas-specific.

3 For special care locations (such as an anaesthetizing area, a recovery area, an intensive care unit or a coronary care unit) where patients are dependent on medical gas and/or medical vacuum, an alternative local source should be available, for example a cylinder or cylinder combination with a pressure regulator, or in the case of medical vacuum, a portable suction unit.

4 When a single cylinder with pressure regulator is used, the cylinder valve and regulator inlet should be of the same type gas-specific connector. The regulator outlet should be gas-specific as required for low-pressure flexible connecting assemblies.

5.1.4 Manifolds shall be of a construction and of a design and materials suitable for the service pressures involved. Manifold cylinder connections broken during cylinder changing operations shall be gas-specific.

5.1.5 All bulk liquid vessel connections shall be gas-specific and non-interchangeable between services. Adaptors are prohibited on the delivery vehicles. The vessel should be fitted with an outlet where a sample can be taken for analysis.

NOTE — A report on the concentration of gas should be provided by the supplier with each shipment of cryogenic liquid medical gases.

5.1.6 All pipeline regulators within a system shall together be capable of controlling pipeline pressure at levels which meet the requirements specified in table 1.

NOTE — Heating of pressure-control regulators or associated pipework may be necessary under high flow conditions to reduce frosting and condensation within the control equipment. Precautions to avoid overheating should be taken.

5.1.7 Control systems shall be designed so that regulators, relief valves, pressure alarm sensors and change-over valves can be maintained without interrupting the gas supply to the pipeline distribution system.

5.1.8 A pressure-relief valve shall be installed downstream of each operating pressure regulator and upstream of the line pressure regulator(s). This relief valve shall be set to lift at a pressure 30 % to 40 % above the nominal operating pressure and shall reach its maximum designed flow capacity (i.e. maximum relief valve full discharge) at a pressure not more than 50 % above its maximum lifting pressure (see figure 2).

5.1.9 A pressure-safety valve shall be installed downstream of line pressure regulator(s) but before the emergency alarm switch and main shut-off valve. This safety valve shall open at a pressure 30 % to 40 % above the nominal line operating pressure and shall reach its maximum designed flow capacity (i.e. maximum safety valve full discharge) at a pressure not

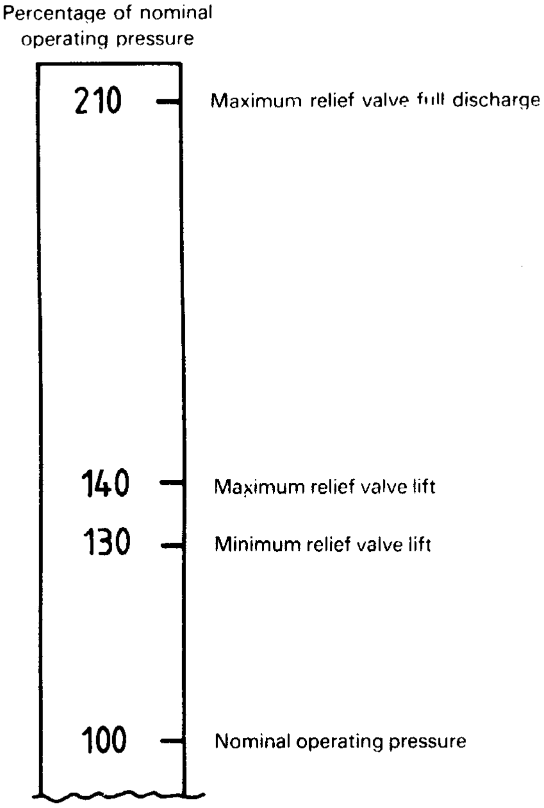

Percentage of nominal operating pressure
210
Maximum relief valve full discharge
140
Maximum relief valve lift
130
Minimum relief valve lift
100
Nominal operating pressure

Figure 2 — Control settings of a pressure-relief valve

more than 60 % above the nominal operating pressure (see figure 3). For a nitrous oxide system the safety valve shall open at a pressure 25 % to 35 % above the nominal line operating pressure and shall reach its maximum designed flow capacity (i.e. maximum safety valve full discharge) at a pressure not more than 55 % above the nominal operating pressure.

NOTE — When a high percentage of nitrous oxide is being used during anaesthesia, a rise of the nitrous oxide pressure above 20 % of the operating pressure would further raise the percentage of nitrous oxide in the gas mixture which could be hazardous to the patient.

5.1.10 Safety/relief valves for air may be vented to the outside of the building. Those for all other gases in single pressure systems shall be vented to the outside of the building.

NOTE — The lower pressure section of a multi-pressure distributing system should be vented to the outside of the building, where practicable.

No shut-off valve or flow-restricting device shall interfere with the operating of these safety/relief valves.

NOTE — To maximize safety and ease of maintenance, it is recommended that a three-way duplex safety/relief valve be fitted.

5.2 Supply system with cylinders

NOTE — Typical supply systems with cylinders are shown in figures 6 and 7.

5.2.1 A cylinder manifold system shall have two banks (or groups) of cylinders which alternately supply the pipeline, each bank having its cylinders connected to a common header with a separate pressure regulator. When the content of the primary bank becomes exhausted, the secondary bank shall come into operation automatically to supply the pipeline.

NOTES

1 A supply system with cylinders may include non-cryogenic cylinders, i.e. as used for the supply of nitrous oxide and carbon dioxide. The requirements of 5.2.1, 5.2.2, 5.2.3 and 5.2.4 apply to such cylinders.

2 When an exhausted bank of cylinders is replaced, the change-over system and alarm system may be reset either manually or automatically.

5.2.2 A non-return valve or manually-operated isolation valve shall be installed at the manifold end of each connecting pipe between each cylinder and the manifold header.

NOTE — The purpose of this valve is to prevent the loss of gas from the cylinders connected to the manifold if the safety/relief device on an individual cylinder should function or a cylinder flexible connection should fail.

5.2.3 A cylinder supply system shall comprise

a) a primary gaseous or cryogenic liquid supply which supplies the pipeline;

b) a secondary gaseous or cryogenic liquid supply which shall operate automatically to supply the pipeline as the primary supply becomes exhausted.

It may also have a permanently connected reserve supply which may be operated manually or automatically in the event of both the primary and the secondary supplies being unable to supply the pipeline.

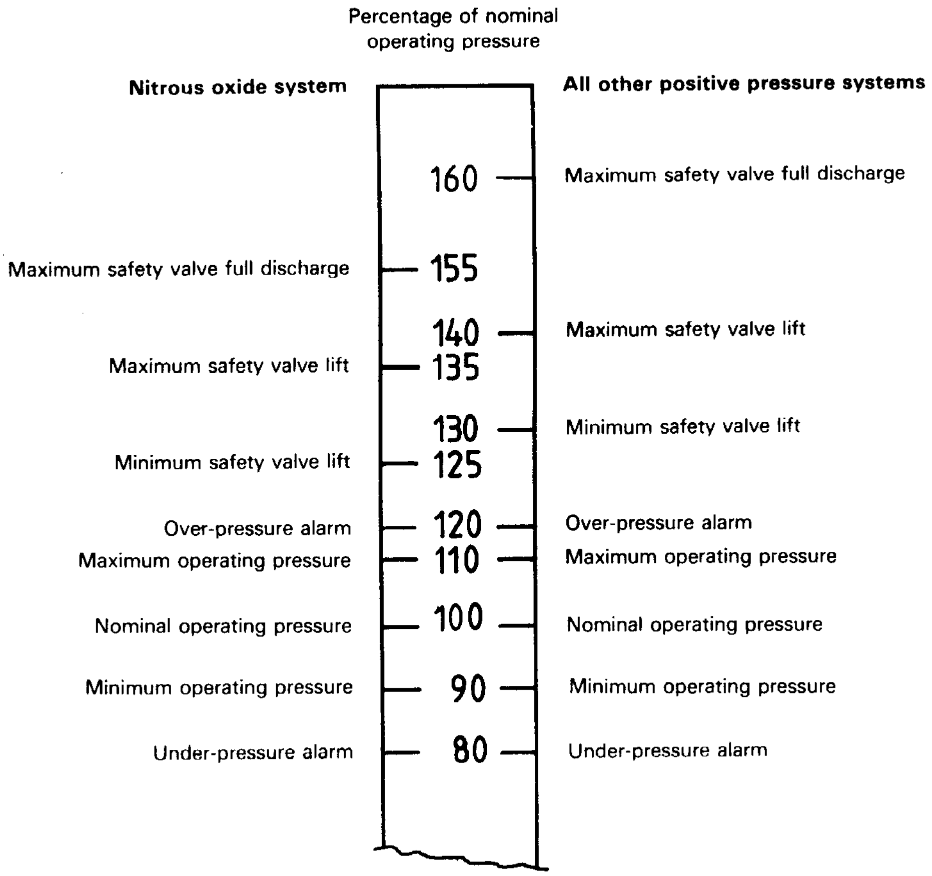

Percentage of nominal operating pressure
Nitrous oxide system
All other positive pressure systems
160
Maximum safety valve full discharge
Maximum safety valve full discharge
155
140
Maximum safety valve lift
Maximum safety valve lift
135
130
Minimum safety valve lift
Minimum safety valve lift
125
Over-pressure alarm
120
Over-pressure alarm
Maximum operating pressure
110
Maximum operating pressure
Nominal operating pressure
100
Nominal operating pressure
Minimum operating pressure
90
Minimum operating pressure
Under-pressure alarm
80
Under-pressure alarm

Figure 3 — Pressure-safety valve and alarm pressure settings

5.2.4 There shall be a supply of gas cylinders in reserve either attached to the manifold, or held in a hospital storage area that is readily available. The volumetric capacity of the reserve supply shall be specified, taking into account the average demand and availability of the gas concerned. (See annex F.)

5.2.5 If a cryogenic liquid cylinder supply is installed, it shall be in accordance with the principles indicated in figure 7.

5.2.6 Cryogenic liquid cylinder supply systems shall be provided with pressure-relief devices on the manifold.

5.3 Supply systems with stationary cryogenic vessels

NOTE — Typical supply systems with stationary cryogenic vessels are shown in figure 8 and the location of stationary cryogenic vessels are specified in 5.8.

5.3.1 The cryogenic supply system shall consist of at least two sources of supply at all times. These may be either of the following:

a) two or more units alternately supplying the pipeline. When the primary supply is exhausted, the secondary supply automatically becomes the primary supply and the secondary supply is refilled after the change-over takes place;

b) one or more units continuously supplying the pipeline while another unit remains as the reserve supply and operates only in case of an emergency.

5.3.2 The reserve supply shall comprise either a liquid or a cylinder supply. The volumetric capacity of the reserve supply shall be specified, taking into account the average demand and availability of the gas concerned. (See annex F.)

NOTES

1 Any secondary and/or reserve supplies should have the designed flow capacity of the primary supply.

2 Where the gaseous or liquid supply is connected upstream of the line regulator, the line regulator and its associated relief valve should be duplexed with isolating valves.

3 In the case of a cylinder supply, additional cylinders should be held in an adjacent store.

5.4 Oxygen concentrator [pressure swing adsorber (PSA)]

If a PSA plant is used for the supply of oxygen-enriched air via a pipeline system, an automatically-operating reserve supply, a means of continuous analysis of oxygen concentration and alarms shall be provided.

NOTES

1 It is intended that an International Standard specifying requirements for PSA plants will be prepared and this clause will be superseded by that International Standard when it is published.

2 Until an International Standard for PSA plant has been developed, it is recommended that before a PSA system is installed, the medical and other responsible staff of the facility agree on the specific use(s) planned. This will ensure that proper guidance is given for the safe management of problems such as

a) gas-specific fittings;

b) labelling;

c) areas of distribution, e.g. operating rooms, intensive care units, emergency departments.

3 It is strongly recommended that the medical oxygen pipeline and its terminal units are not used for piping the output from oxygen concentrators.

4 Further information on PSA plants is given in annex H.

5.5 Medical air systems

NOTE — Typical medical air systems are shown in figures 6, 9, 11 and 12.

5.5.1 General

A central supply system for medical air shall be one of the following:

a) an air compressor system, as specified in 5.5.2;

b) an automatically-controlled proportioning system capable of producing a mixture of approximately 21 % (V/V) oxygen and approximately 79 % (V/V) nitrogen, from a central supply, as specified in 5.7;

c) a cylinder supply system for air, in accordance with 5.2;

d) a combination of the above.

5.5.2 Air compressor system

5.5.2.1 Each central source (see figure 9) shall comprise two or more units of such a capacity that the average calculated demand can be supplied with one unit out of service, and automatic controls arranged so that the units will supply the system in turn or simultaneously according to the demand on the system.

NOTE — The noise level arising from the operation of some compressors may be unacceptable in some situations and appropriate action should be taken.

5.5.2.2 Compressors may be of any type provided there is a means to reduce contaminants to approved levels (see 12.4.7).

5.5.2.3 Each unit shall have a control circuit arranged so that shutting off, or failure of, one unit will not affect the operation of other units.

5.5.2.4 All electrical wiring of the compressor system shall conform to the provisions of IEC Publication 364. Electrical systems shall be connected to both the normal and emergency power supplies. With more than two compressors, not all compressors need to be connected to the emergency power source, provided that an adequate supply of gas can be maintained during an emergency.

5.5.2.5 Receivers, if required, shall be capable of meeting the operational needs of the system.

NOTE — If only one receiver is provided, a by-pass system should be installed for inspection and maintenance.

5.5.2.6 Drains shall be installed on dryers, after-coolers, separators and receivers so that condensate can be drained.

5.5.2.7 The intake for the air system shall be located in a position where there is minimal contamination from internal combustion engine exhausts, vacuum systems, anaesthetic gas scavenging systems, ventilation system discharges and other contaminants. The air intake shall be provided with a filter for protection of components.

5.5.2.8 The air compressor system shall be equipped with at least two dryers, each having the full capacity of the calculated demand, and such filters as are necessary to produce air of the required quality (see 12.4.7), which shall be located upstream of the final pressure-control equipment.

5.5.2.9 Except for air for surgical tools, an air compressor system shall include a duplexed pressure-regulating system to maintain a constant pressure in the pipeline distribution system.

5.5.2.10 A flexible connection may be installed between the compressor and the pipeline to prevent transmission of vibration.

5.5.2.11 After-coolers may be necessary to ensure that the air entering the receiver shall be at or near ambient temperature.

5.5.2.12 If the compressed air supply is extended for non-clinical purposes, the precautions given in annex G shall be observed.

5.6 Medical vacuum systems

NOTE — Typical medical vacuum systems are shown in figure 10.

5.6.1 A central source shall comprise two or more units of such capacity that a minimum of 75 % of the system design flow capacity can be supplied with one unit out of service.

NOTE — The A-weighted sound pressure level arising from the operation of some vacuum pumps measured within the central supply room will exceed 85 dB. This level may be unacceptable in some situations and appropriate action should be taken.

5.6.2 Controls for a central source shall be provided to activate the additional unit(s) automatically should the operating unit(s) of the system be incapable of maintaining an adequate vacuum.

5.6.3 Each unit of the central source shall have a control circuit arranged so that shutting off, or failure of, one unit will not affect the operation of other units.

5.6.4 Electrical wiring of vacuum systems shall conform to the provisions of IEC Publication 364. The electrical source for the units shall be connected to both the normal and standby electrical power supplies. With more than two pumps, not all pumps need to be connected to the emergency power supply provided that an adequate vacuum can be maintained during an emergency.

5.6.5 Reservoirs, if required, shall be capable of meeting the operational requirements of the system.

5.6.6 If a reservoir is installed, a drain shall be fitted.

5.6.7 The exhaust from the vacuum pumps shall be piped to the outside with the end turned down and should be screened against insects. It shall be in a position where risk of contamination of occupied buildings is minimized.

5.6.8 A flexible connection may be installed between the vacuum pump and the pipeline to prevent the transmission of vibration.

5.6.9 Duplicate bacterial filters shall be fitted or other effective methods used to prevent the entry of bacteria into the equipment and to prevent their discharge to atmosphere.

NOTE — The use of a medical vacuum system as a means of evacuation of waste anaesthetic gases is not recommended unless careful consideration is given to the capacity of the system and to the hazard which may occur due to flammable or corrosive gases in the system.

5.7 Proportioning systems

NOTE — A typical proportioning system, for example for blending oxygen and nitrogen to produce air, is shown in figures 11 and 12.

5.7.1 The sources of medical gas for proportioning systems shall conform to the requirements of 5.2 and 5.3 and may be the same sources as those supplying the medical gas pipelines separately.

5.7.2 A central source of medical air employing a proportioning system shall include a reserve supply in the form of a cylinder manifold system which shall be permanently connected and which shall operate automatically.

5.7.3 A proportioning system for air shall operate automatically to produce air of the quality required by 5.5.1. The mixture shall be analysed continuously and the results shall be recorded. The system shall be arranged so that manual intervention is necessary to correct the composition of the air before reconnecting the mixer to the pipeline.

NOTE — Two sets of instruments should be provided, at least one of which is capable of independently and automatically shutting off the gas mixture from the pipeline.

5.7.4 A proportioning system shall be capable of supplying the mixture of the required composition over the entire range of specified flow.

5.7.5 A proportioning system shall include means for verifying the calibration of the analysers and the performance of the instruments by reference to a mixture of known composition.

5.7.6 If a proportioning system is required to supply medical gas mixtures other than air, it shall include all the safety features specified in 5.7.2 to 5.7.5.

5.8 Location of stationary cryogenic vessels

5.8.1 Stationary cryogenic liquid systems shall not be installed over subterranean structures such as underground bunkers, basement rooms, etc., and shall be more than 5 m away from openings to trenches, subterranean structures, manholes, gullies or traps, and at least 3 m from public access routes. (See figure 13.)

5.8.2 Except for vessels located as specified in 5.8.3, stationary cryogenic liquid oxygen and nitrogen vessels shall be installed in a position which is open to the air and at ground level, not on the roof of a building. The control equipment shall be protected from the weather and the area fenced.

5.8.3 If a stationary cryogenic vessel is to be installed inside a building, then it shall be positioned in a room specially constructed for the purpose with adequate ventilation to the open air in order to avoid the hazards of oxygen enrichment or deficiency. An access door and an emergency exit as in 5.10 shall be incorporated in this building.

5.8.4 Adequate access for a vehicle shall be provided so that a cryogenic liquid supply plant can be filled. The ground in the immediate vicinity of an oxygen filling point shall be of concrete or other non-combustible material.

5.9 Location of manifolded cylinders

A supply system with manifolded cylinders may be installed in the open air, with the control panel protected from the weather or especially constructed for operation in the open air, and the area fenced. Alternatively, it may be installed inside a room specially constructed, suitably modified, well ventilated and fire-resistant.

5.10 General requirements for supply plant

5.10.1 Rooms or areas for supply systems shall not be used for any purpose other than for supply plant equipment containing the non-flammable gases that are to be distributed through the pipelines, except that empty cylinders disconnected from the supply equipment may be stored, pending their removal; in addition, one group of full cylinders sufficient for one side of the manifold may also be stored. A separate storage area should be provided for empty cylinders.

NOTE — Only nominated persons should be authorized to operate and attend the plant.

5.10.2 Services containing combustible gases or liquids are not permitted within any manifold room or source supply area.

5.10.3 The ambient temperature in enclosures or rooms for supply systems shall not exceed 50 °C for any gas and shall be not less than 10 °C for nitrous oxide, oxygen/nitrous oxide mixtures and carbon dioxide, unless other means are provided for preventing loss of pressure or gas separation in these cylinders. In the plant room for medical air compressors and vacuum pumps, the temperature shall not exceed 40 °C.

NOTE — Any heating system may be used to heat supply plant enclosures or storage areas, provided that no part of the heating system in contact with the air within the room exceeds a temperature of 225 °C and that the supply plant or cylinders are prevented from coming into direct contact with the heating system.

5.10.4 All electrical fittings in supply rooms shall be located in fixed positions to minimize the risk of physical damage.

5.10.5 Fire fighting equipment shall be provided.

5.10.6 The room or enclosure shall be well ventilated to the open air, and ducting for such ventilation shall not be connected to that serving any other building.

5.10.7 The doors or gates provided to facilitate cylinder handling or plant filling shall be capable of being locked. An emergency exit shall be provided which shall be free from obstruction at all times. All doors shall be capable of being opened from the inside, at any time, without a key. All doors shall open outwards.

5.10.8 Enclosures (interior or exterior) for supply systems shall conform to the following requirements:

a) when enclosures are located near sources of heat such as furnaces, incinerators or boiler rooms, construction shall prevent cylinder temperatures from exceeding 50 °C;

b) they shall not be located within 3 m of open electrical conductors and transformers;

c) they shall not be located adjacent to oil storage tankers;

d) they shall comply with local building codes;

e) they shall have concrete floors;

f) a warning notice shall be clearly displayed on both sides of each door or gate, for example

Warning — Oxygen/nitrous oxide (or chemical symbol, etc., as appropriate)

No smoking

No open flames or sparks

No oil or grease

No combustible material to be placed within 5 m

g) fences and walls shall be of a height not less than 1,75 m.

NOTES

1 Enclosures should be easily accessible to vehicles delivering cylinders or liquid gas and be at ground level or vehicle height according to the method of unloading used.

2 Enclosures should be located so that no part of the enclosure is less than 5 m (for stationary oxygen cryogenic plant) or 3 m (for other supply plant) from any occupied building or from any roadway or footpath.

5.10.9 Vacuum and air compressor plant shall be installed in a well lit, ventilated and clean location with ample accessibility. The location shall be provided with drainage facilities. Vacuum and air compressor plant when installed as a source shall be located separately from other medical gas system sources, and shall be readily accessible for maintenance.

6 Warning systems

6.1 General

6.1.1 Warning systems, whether for operating or emergency purposes, shall comply with the following requirements:

a) the location shall allow continuous observation; alternatively, an auxiliary alarm signal shall be provided at the telephone switchboard, the security guard room or some other suitable location;

b) emergency alarm signals shall be installed in operating theatres and critical care areas, for example intensive care wards and coronary care units;

c) pressure gauges or indicators shall be provided to indicate deviations from normal working pressure range (see figure 3), in suitable places, for example in manned areas of operating theatres and in the vicinity of the nurses' station in critical care areas — these gauges or indicators shall be labelled to indicate the gas and the zone monitored;

d) each warning system shall consist of a visual signal and may include an auditory signal — the visual signal shall persist until the cause of this signal is corrected;

NOTE — It may be possible to silence the activated auditory signal for a maximum period of 15 min.

e) each signal shall be labelled according to its function;

f) the colour of visual signals shall comply with IEC Publication 601-1;

g) the sensing device for all warning systems shall be located so as to ensure the monitoring of normal operation and emergency conditions;

h) means shall be provided for testing the activation mechanism and electrical integrity of visual and auditory alarms;

i) a pressure-sensing device shall not be isolated, for example by a stop valve, from the pipeline to which it is connected — if a valve or flow-limiting device is incorporated for maintenance purposes, it shall be opened by the insertion of the sensing device.

6.1.2 When operated electrically, warning systems shall be connected to both the normal and standby power supplies.

NOTE — Systems should normally be electrically energized so that the alarm is initiated on electrical failure between the sensor and indicator.

6.2 Operation alarms

6.2.1 All operation alarms shall be visual.

NOTE — Auditory alarms should be provided for the alarms listed in 6.2.2. a), c) and d).

6.2.2 Alarms shall be provided to indicate

a) change-over from primary to secondary supply;

b) reserve supply going into operation in automatic systems, or the need to bring manual reserves into operation;

c) when the liquid level in the operating cryogenic vessel has reached 30 % of the liquid capacity;

d) when the liquid level in the reserve cryogenic vessel has fallen to 50 % of the capacity;

e) malfunction of thermal pressure control systems in bulk nitrous oxide and carbon dioxide supplies;

f) malfunction of medical air compressors and vacuum pumps.

NOTE — Alarms should also be provided to indicate

a) increase in moisture content in compressed air pipelines;

b) decrease in any reserve supply to below 50 % of its capacity.

6.3 Emergency alarms

6.3.1 All emergency alarms shall be visual and auditory.

6.3.2 Emergency alarms shall be provided to indicate

a) low mainline pressure in pipelines, i.e. when the pressure monitored falls 20 % below the nominal working pressure;

b) high mainline pressure in pipelines, i.e. when the pressure monitored rises 20 % above the nominal working pressure;

c) malfunction of a proportioning system or oxygen concentrator.

6.3.3 When nitrous oxide is delivered, an alarm shall be provided to indicate high line pressure downstream of every final nitrous oxide line regulator serving critical care areas and operating theatres.

7 Requirements for pipelines

7.1 Pipelines and fittings including connecting assemblies shall provide the system design flow within the specified pressure drop limits as given in table 1.

NOTE — Connecting assemblies in a pipeline's distribution system are normally used

a) as a part of the main pipeline, for example for isolation of vibration, building movement and relative movement of the pipelines;

b) for emergency supply of gas to a pipeline;

c) as part of permanently fixed equipment such as booms, pendants and pendant tracks.

Table 1 — Allowable pressure drop between source and terminal unit outlet

Service	Allowable pressure drop[1] between source[2] and the terminal unit outlet
	% of gauge pressure
Medical gases	10 %
Vacuum	20 %
Nitrogen and air for surgical tools	25 %

[1] The pressure drop is that allowable for the system operating at its design capacity, calculated in accordance with appropriate diversity factors.

[2] Where the system includes one or more line pressure regulators, the "source" pressure is the delivery pressure of the last regulator.

7.2 If a connecting assembly is readily accessible to the user, or regularly removed for maintenance, for example in a ceiling flexible pendant or a rigid ceiling column with access panels, the connecting assembly shall be gas-specific (see ISO 5359).

7.3 If a connecting assembly is not readily accessible to the user without significant disassembly of fixed equipment such as hinged-arm booms, tracks and pendants, connectors of the assembly need not be gas-specific. In all cases, the tests specified in 12.3 and 12.4 shall be carried out following any repair and reattachment of the assembly.

7.4 If the connecting assemblies are part of the main pipeline, for example when used for isolation of vibration, building movement and relative movement of the pipelines, and are not normally replaced during their life, the assembly need not be gas-specific. These flexible components shall be tested as part of the main pipeline in accordance with 12.3.1.

8 Shut-off valves

8.1 Shut-off valves are classified as follows:

a) service shut-off valves:

  1) main service shut-off valve,

  2) riser service shut-off valve,

  3) lateral service shut-off valve,

  4) equipment service shut-off valve;

NOTE — These valves should only be used by the maintenance and operating staff and should not be accessible to unauthorized persons. Valves which cannot be locked in the open or closed position should be protected against improper operation.

b) zone shut-off valves in boxes with fixed covers or doors.

NOTE — These valves are accessible and are used to isolate areas within health care facilities for maintenance purposes and in case of emergency. Their operation in the latter case should be included as part of the emergency disaster plan.

8.2 All shut-off valves in a medical gas pipeline system except those in the source of supply (see clause 5) and those in terminal units (see clause 9) should be ball or diaphragm valves. It should be apparent by observation whether the valve is open or closed.

8.3 Boxes enclosing zone shut-off valves shall have fixed covers or doors which can be locked in the closed position. The covers or doors shall have a means of quick access in case of emergency.

8.4 All shut-off valves shall be identified

a) to indicate the gas service name or symbol;

b) to indicate, in a manner appropriate to their classification as specified in 12.2, the zone, area, section of pipeline being served or their purpose.

This identification shall be secured to the valve, valve box, or service pipeline (as specified in 10.1) and be readily visible at the valve site.

8.5 All zone shut-off valves for operation in an emergency shall be within normal hand height and not concealed.

8.6 The main medical gas supply pipelines shall be provided with a service shut-off valve adjacent to the source of supply.

8.7 Each riser from a main shall be provided with a service shut-off valve.

NOTE — Such shut-off valves may be provided for other branches.

8.8 Except for vacuum systems, a zone shut-off valve shall be provided in each gas pipeline serving an anaesthetizing and/or critical care area.

NOTE — One or more associated anaesthetizing locations may be considered as one area.

8.9 Except for vacuum systems, all zone shut-off valves shall be provided with a means to allow physical separation of the downstream pipeline for maintenance and modification.

8.10 If zone shut-off valves are provided with a pipeline connecting point, this point shall be gas-specific (see 11.1.8).

9 Terminal units[1]

NOTE — Principal components of a typical terminal unit are shown in figure 4.

9.1 Each terminal unit shall accept only the appropriate gas-specific connector on an item of medical equipment or its connecting assembly. The socket assembly shall be the body of a DISS or NIST screw-type connector or a quick-connect socket.

9.2 Each terminal unit shall be

a) equipped with a non-interchangeable gas-specific connection point (socket assembly);

b) provided with a terminal unit check valve (automatic closing) which will open the gas supply when the connection is made and which will shut off automatically when the connection is broken;

c) equipped with a terminal unit maintenance valve usually located in the base block, which may be manual or automatic, to permit maintenance without turning off the zone shut-off valve to the unit (this need not apply to vacuum units). This valve shall not be the same valve as in b).

NOTE — The maintenance valve may be omitted only in the case where pipeline systems are duplicated or where a shut-off valve serves a single terminal unit.

d) designed to prevent accidental interchange of any gas-specific internal parts and bodies between terminal units of different gases;

e) permanently and legibly labelled with the name of the gas or symbol and may additionally be colour coded according to ISO 32 — lettering shall have a minimum height of 3 mm;

f) installed at a height which is easily accessible but which minimizes the risk of damage from furniture and equipment.

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[1] Terminal units will be dealt with in a future International Standard.

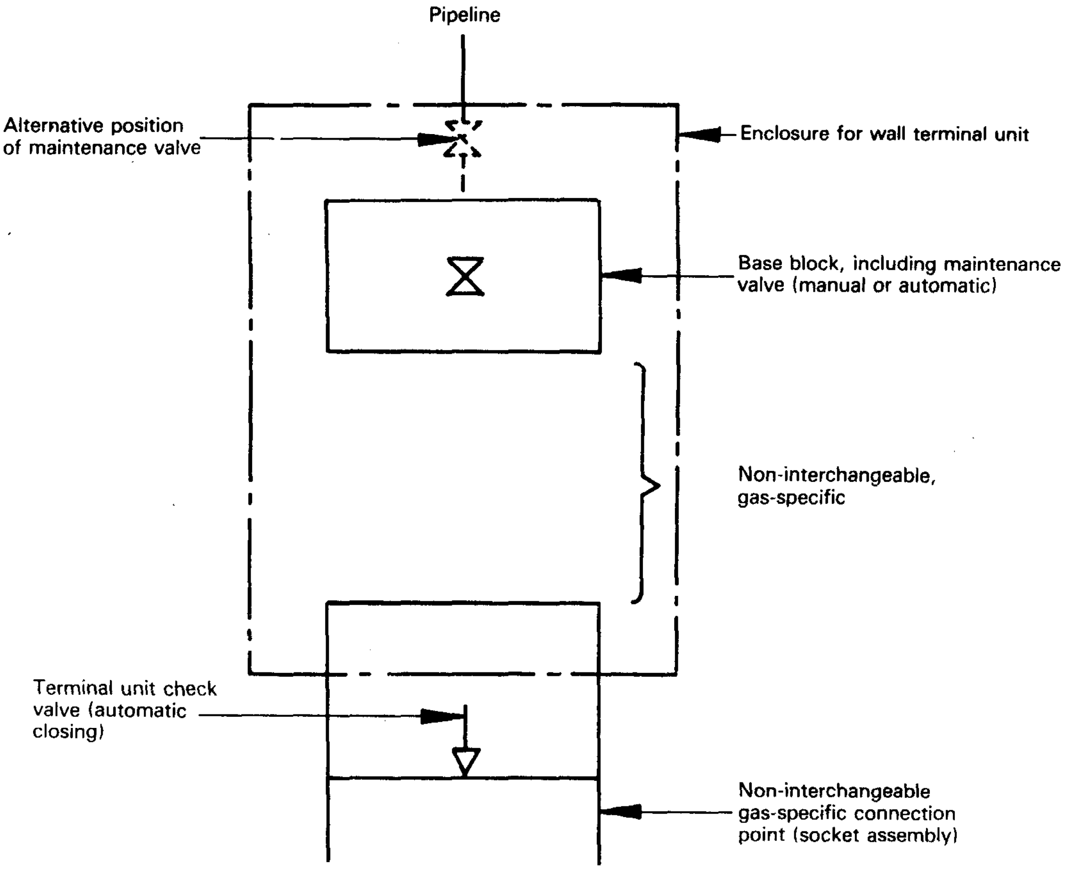

Pipeline
Alternative position of maintenance valve
Enclosure for wall terminal unit
Base block, including maintenance valve (manual or automatic)
Non-interchangeable, gas-specific
Terminal unit check valve (automatic closing)
Non-interchangeable gas-specific connection point (socket assembly)

Figure 4 — Schematic representation of principal components of a typical terminal unit

10 Identification of pipelines

10.1 Pipelines shall be identified and labelled with the gas name or symbol and colour, adjacent to shut-off valves, at junctions and changes of direction, before and after walls and partitions, etc., at intervals of not more than 10 m and adjacent to terminal units.

Such labelling shall be durable and effected, for example, by means of metal tags, stencilling, stamping or with adhesive markers.

10.2 Identification shall be

a) coloured and lettered in accordance with ISO 32, with letters not less than 6 mm high;

b) applied with the words and symbols to be read along the longitudinal axis of the pipeline.

NOTE — Identification should include arrows denoting direction of flow.

10.3 If a pipeline is painted for all or part of its length the colour(s) shall be in accordance with ISO 32 and the gas name or symbol shall also be applied as required in 10.2.

11 Installation requirements for pipelines

11.1 General

11.1.1 Pipeline systems shall be used only for patient care. No connections shall be made into systems for other uses except for the compressed air system, when extensions of use are permitted in accordance with the requirements of 1.3, annex G, and figure 9.

11.1.2 Except when pipelines and electrical services are run in separate compartments, pipeline systems shall be separated from electrical services

a) by more than 50 mm in normal pipeline installations;

b) by more than 10 mm when installed in pendants or similar equipment.

11.1.3 The pipeline shall be bonded to an earth terminal as near as possible to the point at which the pipeline enters the building. The pipelines shall not themselves be used for earthing the electrical equipment. The relevant parts of IEC Publication 364 shall be observed.

11.1.4 Pipelines exposed to physical damage, for example damage which might be sustained from the movement of portable equipment, such as trolleys, stretchers and trucks, in corridors and in other locations, shall be protected.

11.1.5 Unprotected pipelines shall not be installed in areas of special hazard, e.g. in areas where flammable materials are stored. Where installation of pipelines in such a location is unavoidable, the pipeline shall be protected by an enclosure which will prevent the liberation of medical gas within the room should leaks occur in the pipeline system installed in the area.

11.1.6 Buried pipelines shall be protected from frost, corrosion and physical damage.

NOTE — Ducts or casings may be used. Pipelines may be placed in the same tunnel, trench or duct with fuel gas pipelines, electrical lines or steam lines, provided the pipelines are more than 50 mm from other services.

Medical gas pipelines shall not be placed in a tunnel, trench or duct where there is exposure to oil.

NOTE — Ducts in which pipelines are installed should be ventilated.

11.1.7 Pipelines shall not be located in elevator shafts.

NOTES

1 Pipelines may be installed in vertical shafts if they are protected against physical damage, excessive heat, corrosion and contact with oil.

2 A full-bore purge valve with a preceding lockable shut-off valve may be provided at the bottom of each main vertical riser.

11.1.8 A test or purge valve fitted adjacent to each zone shut-off valve shall be capped and sealed, and fitted with a gas-specific connection.

NOTE — It is not necessary to run pipelines with a "fall" for drainage purposes.

11.1.9 A shut-off valve shall not be installed where a leak is likely to cause an accumulation of gas, for example in a sealed cavity.

11.1.10 Contact with corrosive materials shall be avoided by the use of impermeable non-metallic materials applied to the outer surface of the pipework in the area where contact can occur.

11.1.11 Allowance shall be made for expansion and contraction of pipelines.

NOTE — Attention is drawn to national building requirements and fire regulations.

11.1.12 A pipeline for medical air shall be routed in such a way that it is not subject to a temperature below the dew point at the operating pressure.

11.1.13 If a hyperbaric chamber is provided for medical treatment, it may be necessary to instal a separate pipeline(s) and the appropriate pressure- and flow-control equipment.

11.2 Pipeline supports

11.2.1 Medical gas pipelines shall be supported at intervals as shown in table 2, sufficient to prevent sagging or distortion.

Table 2 — Recommended intervals between copper pipeline supports

Outside diameter mm	Maximum intervals m
up to 15	1,5
22 to 28	2,0
35 to 54	2,5
greater than 54	3,0

11.2.2 The supports shall ensure that the pipeline cannot be displaced accidentally from its position.

11.2.3 The supports shall be of corrosion-resistant material, or shall be treated to prevent corrosion. The supports shall be treated or isolated from the pipeline to minimize electrolytic corrosion.

11.2.4 Where pipelines cross electric cables, the pipelines shall be supported adjacent to the cables (see 11.1.2).

11.2.5 Pipelines shall not be used as a support for or be supported by other pipelines or conduits.

11.3 Pipeline joints

11.3.1 Except for threaded joints used in shut-off valves, including terminal unit valves, and where plastics materials are used for vacuum systems, all joints shall be hard-soldered or welded.

NOTE — Threaded joints used in shut-off valves, including terminal unit valves, may be made by tinning the male thread with solder, by using approved sealing compounds or tape or they may be made as part of a compression joint.

11.3.2 During the brazing of pipeline connections, the interior of the pipeline shall be purged with carbon dioxide, argon or nitrogen, except when performing small extensions, final connections or emergency repairs.

11.4 Connection and modifications to existing systems

11.4.1 Connections to an existing system shall be undertaken in only one gas system at a time.

NOTE — Careful consideration should be given to the location of this connection to minimize problems of access in installation and testing.

11.4.2 Where an addition is to be made to an existing system, the new pipeline take-off shall be equipped with a zone shut-off valve at the intended point of connection to isolate the existing pipeline, except when an existing zone shut-off valve can be used for this purpose.

11.4.3 During construction, the valve required by 11.4.2 shall be locked in the closed position and labelled as follows:

Construction isolation valve — DO NOT OPEN

All terminal units affected shall be temporarily marked to indicate they are not to be used.

11.4.4 When modifications are carried out to existing systems, mechanical disconnection at the nearest zone shut-off valve shall be made. A closed valve is not considered adequate mechanical disconnection.

11.4.5 When the appropriate tests specified in clause 12 have been successfully completed on the addition, the connection may be made to the existing system. The valve in 11.4.2 shall be opened and further relevant tests completed on the addition.

11.4.6 When an addition has been completed and tested in accordance with clause 12, all labels as specified in 11.4.3 shall be removed.

11.5 "As-installed" drawings and maintenance manuals

11.5.1 A separate set of "as-installed" mechanical drawings which show the variations of the pipeline system from the contract drawings shall be maintained during construction, and shall be brought up to date as variations are made. These drawings shall include details which will enable buried or concealed pipelines to be located.

11.5.2 Complete "as-installed" drawings specified as in 11.5.1 shall be presented to the owner of the pipeline system as a set of reproducible drawings, marked "as-installed", for inclusion as part of the permanent record of the pipeline system.

11.5.3 If a pipeline system is altered subsequent to the transfer of the drawings to the owner, the "as-installed" drawings as specified in 11.5.2 shall be brought up to date.

11.5.4 Maintenance schedules, instruction manuals, recommended spare parts list and electrical diagrams for the complete installation shall be provided by the installer to the owner.

12 Testing and commissioning

NOTE — The aim of testing and commissioning of medical gas pipeline systems is to verify that all safety aspects and performance requirements of the systems are met. An example of a procedure for testing and commissioning is given in annex C.

12.1 General requirements for tests

12.1.1 All tests after complete installation shall be carried out or witnessed by a responsible testing authority or by designated qualified persons who shall certify the results of the tests to the owner or client.

NOTE — The fields of responsibility of the different persons or authorities participating in the tests should be clearly defined before testing begins.

12.1.2 Purging and testing as in 12.2.2 shall be carried out with clean, oil-free dry air, nitrogen or carbon dioxide, except for those tests where the specific gas is prescribed.

12.1.3 Before any testing is carried out, every terminal unit in a system under test shall be labelled to indicate that the system is under test and that it shall not be used.

12.1.4 The results of tests made for certification purposes shall be part of the permanent records of the hospital and shall show details of the services and areas tested.

12.2 Tests to be carried out

12.2.1 Tests after installation of piping with base block of terminal unit fitted but before concealment

The following tests shall be carried out:

a) leakage test;

b) tests for cross-connection and obstruction;

c) visual check that identification of pipelines complies with the requirements specified in clause 10.

12.2.2 Tests and procedures after complete installation and before use of the system

The following tests and procedures shall be carried out:

a) tests and checks for leakage, correct zoning and identification of zone isolation valves — check for identification of terminal units;

b) tests for cross-connection, flow, pressure drop, and system performance;

c) tests of pressure-relief valves and safety valves;

d) functional test of all sources of supply;

e) test of warning systems;

f) purging and filling with specific gas;

g) tests for cleanliness;

h) tests for gas identities.

NOTE — Further testing in accordance with 12.2.2 may be required if significant delay occurs before use of the system.

12.3 Requirements for tests listed in 12.2.1

12.3.1 Leakage

There shall be no pressure drop within a 24 h period except for pressure changes due to temperature variations (see annex B), when tested at a minimum pressure of 1,5 times operating pressure for medical gas pipelines and 500 kPa for vacuum pipelines.

NOTE — With large volume systems, it may be preferable to test small sections of the system individually.

12.3.2 Cross-connection and obstruction

There shall be no cross-connection or obstruction.

12.4 Requirements for tests listed in 12.2.2

12.4.1 Leakage, correct zoning and identification of shut-off valves; check for identification of terminal units

12.4.1.1 Leakage from total compressed medical gas systems

After a 24 h period under test at nominal operating pressure, a pressure drop may be observed in the system. The pressure drop shall not exceed the value calculated from the formula

$$\Delta p = \frac{48\,n}{V}$$

where

Δp is the gauge pressure drop, over 24 h, in kilopascals;

n is the number of terminal units;

V is the volumetric capacity, in litres, of the pipeline system.

NOTES

1 The formula is based on a maximum permissible leakage of 0,48 l/24 h per terminal unit.

2 With large volume systems, it may be preferable to test small sections of the system individually.

12.4.1.2 Leakage from total vacuum systems

With the system at nominal operating vacuum and with the source isolated, the pressure in the pipeline shall not exceed 10 kPa after 1 h.

12.4.1.3 Leakage from shut-off valves for compressed medical gases

With the system upstream of the closed valve under test at nominal operating pressure, the downstream line depressurized and all downstream terminal units closed, there shall be no pressure increase downstream from the valve, or leak to the environment, over a period of 15 min.

12.4.1.4 Check for correct zoning and identification of shut-off valves

A check shall be made that each shut-off valve is properly identified and controls only those terminal units intended by the design.

12.4.2 Cross-connection, flow and pressure drop

12.4.2.1 Cross-connection

There shall be no connections between pipelines for different gases and vacuum. If this test is combined with the gas identity test, the specific gas shall be used.

WARNING — Serious consequences for patient safety could result if this test is not carried out completely and correctly.

12.4.2.2 Flow and pressure drop

The pipeline pressure drop shall not exceed the values in table 1 when the system is tested at its designed flow and measured at each terminal unit.

12.4.3 Pressure-relief valves and -safety valves

Where type-tested pressure-relief and -safety valves are installed, a special valve test is not required.

12.4.3.1 Pressure-relief valves

The performance of pressure-relief valves shall be in accordance with 5.1.8.

12.4.3.2 Pressure-safety valves

The performance of pressure-safety valves shall be in accordance with 5.1.9.

12.4.4 Functional tests of sources of supply

The source of supply shall be tested for normal and emergency operating conditions according to the manufacturer's manuals and specifications which are required by 11.5.4.

12.4.5 Warning systems

The performance of warning systems shall be tested in all operating and emergency conditions.

12.4.6 Purging and filling with specific gas for compressed medical gases

Each distribution system shall be purged with its specific gas for a sufficient number of times to displace the test gas. Each terminal unit shall be purged to ensure that no pockets of test gas remain.

12.4.7 Cleanliness

The pipeline shall be tested for contamination after purging and filling with its specific gas as specified in 12.4.6.

12.4.7.1 Particulate matter

All terminal units shall be tested for the absence of visible particulate matter.

NOTES

1 This test mav be combined with the purging procedure specified in 12.4.6.

2 When tested as described in C.6.1, there should be no particulate matter visible in good light to an operator with normal vision.

12.4.7.2 Oil

Selected terminal units shall be tested for oil contamination by the absence of odour or taste. The oil level shall not exceed 0,5 mg/m^3.

12.4.7.3 Water vapour

In air pipelines supplied from compressors, the dew point measured at selected terminal units shall not exceed + 5 °C at pipeline pressure (see 11.1.12).

12.4.7.4 Carbon monoxide and carbon dioxide

Air pipelines using compressors as a source shall be tested for carbon monoxide and carbon dioxide. The levels shall not exceed 5 ppm (V/V) for carbon monoxide and 1 000 ppm (V/V) for carbon dioxide.

12.4.8 Gas identity

A gas identity check shall be carried out on each terminal unit after purging with its specific gas.

NOTE — This may be carried out during the cross-connection test specified in 12.4.2.1.

A device for the measurement of oxygen concentration at each terminal unit shall be used. [The nominal measurements will be 100 % (V/V) for oxygen terminal units; 21 % (V/V) for medical air terminal units; 50 % (V/V) for oxygen/nitrous oxide mixture terminal units; and 0 % (V/V) for nitrous oxide, helium, nitrogen and carbon dioxide terminal units.]

NOTES

1 This test will not give a positive indication of nitrous oxide, helium, nitrogen and carbon dioxide pipelines.

2 Attention is drawn to national regulations governing the purity of compressed medical gases.

12.5 Minimum requirements for certification of systems

12.5.1 Before a medical gas pipeline system is used, a responsible testing authority shall certify in writing that all tests and procedures in 12.4 have been completed and that all systems comply with the requirements.

NOTE — The testing authority should certify that all drawings and manuals, as required in 11.5, have been supplied to the owner or client.

12.5.2 Certificates shall be dated and signed by the responsible testing authority, the representative of the owner and the representative of the installer.

12.5.3 When all tests have been completed satisfactorily, all construction labels which have been fixed to terminal units shall be removed prior to handover.

Annex A

Preferred uses and restrictions of materials

(This annex forms an integral part of the standard.)

A.1 Materials

This annex gives recommendations and restrictions with regard to the requirements for materials and jointing techniques.

Table 5 covers jointing methods only for pipes and fittings and states that brazing is recommended for joining copper pipe (for nitrous oxide for example) but that welding copper pipes is permitted, but not in common use.

A.2 Metals

NOTE — Table 3 refers to metals for use up to 1 400 kPa only.

Table 3 — Preferred uses and restrictions for metals

Type of material	Restrictions on use	Use preferred for
Aluminium wrought and cast alloys	Not suitable for gases containing moisture Application limited for oxidizing gases	Joints and seals, valve bodies
Copper, pure		Pipelines, joints and seals
Copper-zinc alloys (brass types), copper-nickel zinc alloys, copper-tin alloys		Metallic joints, filters and sieves, valve bodies and fittings, terminal units
Mild steel, cast steel, cast iron	Not permitted for oxygen if the gas velocity is higher than 25 m/s up to a pressure of 4 000 kPa	Valve bodies and fittings
Stainless steel (alloy similar to, or higher than, Cr-Ni-17/7)		Pipelines, springs, filters, sieves, valve bodies and fittings
Monel metal		Valve bodies and fittings, pressure gauge operating tubes

NOTE — Copper is the material normally used for pipelines.

A.3 Non-metals

Table 4 — Applications for non-metals

Type of material (chemical name)	Abbreviation	Oxygen	Oxygen mixtures	Air	Nitrous oxide	Inert gases, nitrogen, carbon dioxide and vacuum
Chloroprene rubber	CR	0	0	0	+	+
Isobutene-isoprene rubber	IIR	0	0	+	+	+
Polyethylene	PE	0	0	+	+	+
Polyamide	PA	0	0	+	+	+
Polyvinyl chloride	PVC	0	0	0	0	+
Polytetrafluoroethylene	PTFE	0	0	+	+	+
Polychlorotrifluoroethylene	PCTFE	0	0	+	0	+
Copolymer of hexafluoropropylene and vinylidenefluoride	—	0	0	+	0	+

+ denotes "recommended", 0 denotes "permitted", see note 2.

NOTES

1 Certain non-metallic materials give off noxious or toxic vapours at elevated temperatures.

2 Non-metallic materials exist in various qualities. All non-metallic materials, even PTFE and PCTFE, can be hazardous in some situations (e.g. at cylinder pressure); therefore ask the producer of the material for the field of application with respect to gas, pressure, velocity, etc., and if necessary test before specifying.

A.4 Jointing methods

Table 5 — Jointing methods

Types of joints	Application	Pipe material[1]	
		Stainless steel	Copper
Welding		+ [2]	0
Brazing	Soldering sockets, fittings, butt-soldering	0	+
Mechanical joints	Flanged types	+	+
	Screw connections	+	+
	Compression pipe fittings	+	0
Sealing materials for mechanical joints	Aluminium flat sealing washer	+	0
	Other metallic sealing	+	+
	Metal-impregnated sealing	+	+
	Non-metallic sealing	+ [3]	+ [3]

+ denotes "recommended", 0 denotes "permitted", but not in common use.

1) Pipe specifications should be in accordance with ISO 65 for steel and ISO 274 for copper or national standards. For vacuum systems, plastic pipe may be used and appropriate jointing techniques applied, for example welding, cementing.

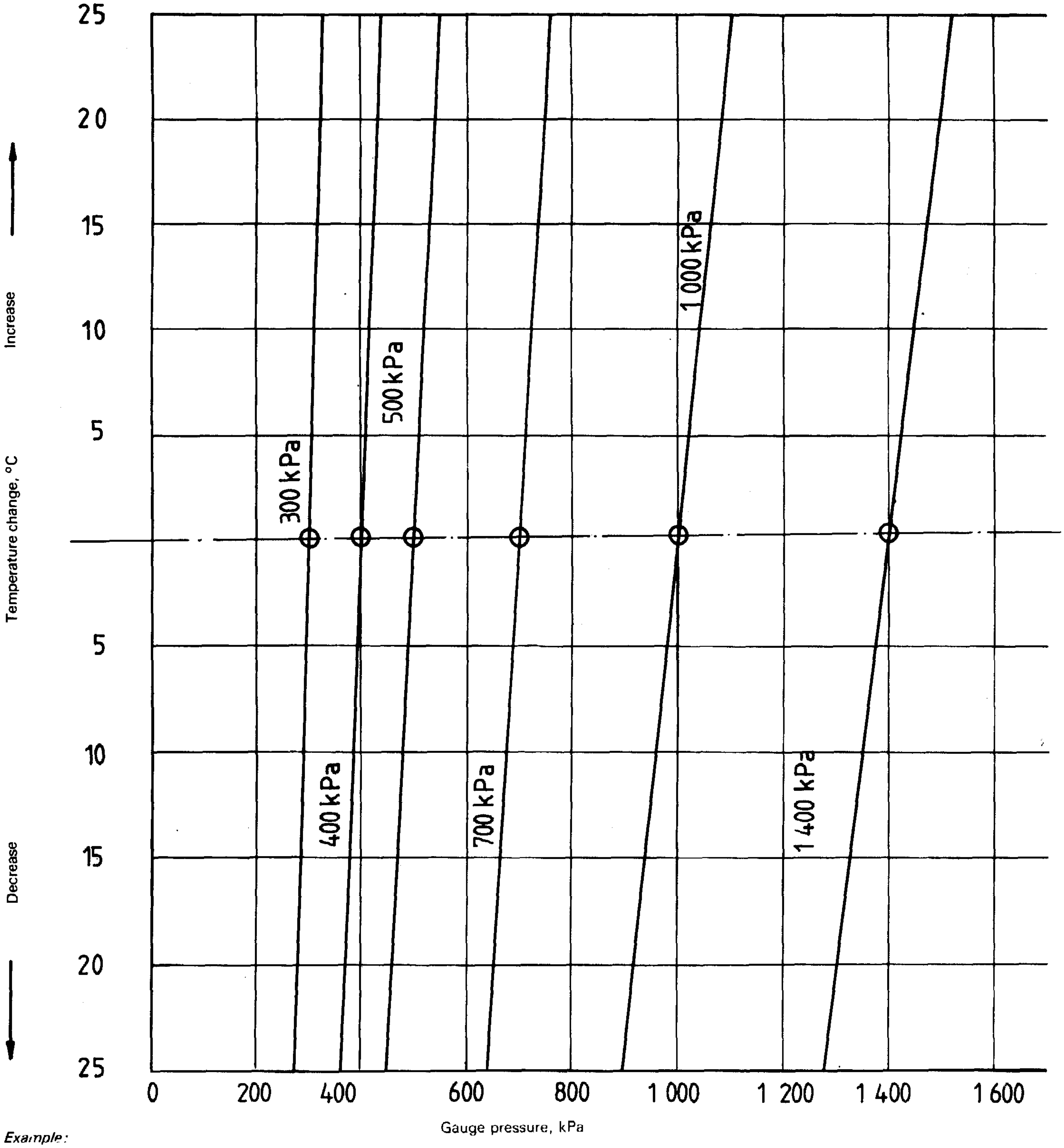
2) Pressure-velocity limitations, see table 3, or national standards where they exist.

3) Oxygen-proof sealing materials should be approved by the respective national authorities where these exist.

Annex B

Temperature and pressure relationships

(This annex forms an integral part of the standard.)



Example:

The pressure of a system previously at 1 400 kPa will fall to 1 350 kPa with a 10 °C fall in temperature.

Figure 5 — Relationship between temperature and pressure at typical pipeline pressures

Annex C

A procedure for testing and commissioning medical gas pipeline systems

(This annex forms an integral part of the standard.)

C.0 Introduction

This testing procedure is given as an example of how the specification of clause 12 may be verified. Other procedures may be devised which validly test this specification. In this procedure the given sequence of tests is important and should be followed.

C.1 Tests after installation of piping with base block of terminal unit fitted (see 12.3)

C.1.1 Leakage test

This test may be carried out on sub-sections of the pipeline, provided that no part of the system is omitted. More than one pipeline may be tested at the same time.

C.1.1.1 General conditions

The section to be tested should be completely installed and fixed to the wall.

The base blocks of all terminal units should be fitted and blanked.

Other devices such as pressure gauges and pressure switches need not be fitted. All connection sockets for such devices should be blanked.

A test pressure gauge should be connected to the section under test.

The section under test should be isolated from the remainder of the system.

C.1.1.2 Procedure

Fill the section(s) to be tested with test gas at a pressure of 1,5 times operating pressure for compressed medical gases and 500 kPa for vacuum.

Disconnect and remove the gas supply.

Note the pressure shown on the gauge initially and again after 24 h.

Note the temperature at the beginning and end of the test.

C.1.1.3 Results

No pressure drop should occur except for pressure changes due to temperature variations. (See annex B.)

C.1.2 Tests for cross-connection and obstruction

These tests should be carried out on one pipeline at a time, and if possible on the completed system. It is also advisable to check the cleanliness of the pipeline during these tests by suitable observation.

C.1.2.1 General conditions

All pipeline systems should be at atmospheric pressure.

A single pressure source should be used and connected to only one system at a time.

The system under test should remain pressurized at working pressure throughout the test.

At least one base block on all other systems should be open to the atmosphere.

All zone isolation valves on all systems should be open during all tests.

C.1.2.2 Procedure

Test each terminal unit on the system under test as follows:

a) open the base block to its maximum;

b) permit the test gas to flow for approximately 1 min and check flow and cleanliness;

c) re-blank the base block;

d) remove pressure source after the last opening has been closed again and leave the connection point open;

e) connect the pressure source to the next gas system and test in accordance with procedures a) to d).

NOTE — After completion of all tests, re-blank all terminal unit base blocks. It is advantageous to leave the piping systems under pressure after these tests are completed. If this is not done, and there is a lapse of time, a retest for leakage should be carried out before final installation of the terminal unit valves.

C.1.2.3 Test results

There should be an adequate flow of test gas from every base block on the system under test and no flow from those base blocks left open on other systems.

The test gas should be observed to be free from particulate matter (see C.6.1).

NOTES

1 If the flow is too low, there is an obstruction in the piping system which should be remedied.

2 If there is no flow from a terminal unit, that terminal unit is wrongly connected or totally obstructed. This situation should be investigated and rectified and the terminal unit retested.

3 If there is flow from the open base block on a system not under test, that system is cross-connected with the one under test. This should be investigated, rectified and retested.

C.1.3 Identification of pipelines

C.1.3.1 General conditions

All pipeline systems being checked should be completed to identifiable points, e.g. valve box, terminal unit, source equipment.

C.1.3.2 Procedure

Visually inspect that the identification has been correctly placed on all pipelines, especially adjacent to tees and where pipelines pass through walls and partitions.

Ensure that the gas name, symbol and colour are correct and that identification is firmly attached.

If the inspection involves isolation valves, terminal units and source equipment, ensure that the gas identity on such equipment matches that on the pipelines.

C.1.3.3 Test results

The identification of all pipelines should be as specified in clause 10.

C.2 Tests after completion of the installation

C.2.1 Tests and checks for leakage on compressed medical gas pipelines

NOTE — All systems may be tested at the same time.

C.2.1.1 General conditions

The leakage test described in C.1.1 should have been completed satisfactorily.

All terminal unit valves and other devices such as pressure gauges and relief valves should have been installed.

A pressure source should be connected to the system(s) under test at a convenient point.

A test pressure gauge should be connected to the section(s) under test.

C.2.1.2 Procedure

Fill the system(s) to be tested with test gas at operating pressure.

Disconnect and remove the gas supply.

Note the pressure shown on the gauge initially and again after 24 h.

C.2.1.3 Test results

Any pressure drop should be as specified in 12.4.1.1.

C.2.2 Tests and checks for leakage on vacuum pipelines

C.2.2.1 General conditions

The leakage test described in C.1.1 should have been completed satisfactorily.

All terminal unit valves and other devices such as pressure gauges and relief valves should have been installed.

The vacuum source should be connected to the system(s) under test.

A test pressure gauge should be connected to be section(s) under test.

C.2.2.2 Procedure

Evacuate the system(s) to nominal operating vacuum and maintain the source in use until the system(s) is (are) dried out. With the system at nominal operating vacuum, isolate the vacuum source. Note the pressure shown on the gauge initially and after 1 h.

C.2.2.3 Test results

Any reduction in the level of vacuum should be as specified in 12.4.1.2.

C.2.3 Correct zoning, tightness and identification of shut-off valves

These tests may be carried out on more than one system at a time. Valve tightness tests are not necessary on vacuum systems.

C.2.3.1 General conditions

The tests specified in C.2.1 should have been completed satisfactorily and all terminal unit valves closed.

C.2.3.2 Procedure

C.2.3.2.1 The system should be at operating pressure.

C.2.3.2.2 Close all zone isolation valves.

C.2.3.2.3 On all systems, depressurize the line downstream of the most remote valve from the source, by opening a terminal unit valve.

C.2.3.2.4 Close the terminal unit valve and reopen after 15 min.

C.2.3.2.5 On each system, open valves in sequence towards the source of supply repeating procedures C.2.3.2.3 and C.2.3.2.4.

C.2.3.2.6 Check all valves, in both open and closed positions, for leakage into the environment.

C.2.3.2.7 After procedures C.2.3.2.1 to C.2.3.2.6, check areas served by each valve and its identification.

C.2.3.3 Test results

On compressed medical gas pipelines, no pressure increase should occur in the pipeline downstream of the valve under test.

Each valve should serve only the area(s) intended by the system design, and be so identified.

Valves should not leak into the environment.

C.2.4 Tests for cross-connection, identification, flow, pressure drop and mechanical function of terminal units

Total system flow and pressure drop tests (see C.2.5) may be carried out in association with these tests.

In no circumstances should these tests be carried out on more than one system at a time.

C.2.4.1 General conditions

All pipeline systems should be at atmospheric pressure.

All zone isolation valves on all systems should be open during all tests.

A single pressure source should be used and connected to only one system at a time; in the case of vacuum systems, this should be the vacuum source.

The system under test should remain pressurized at nominal operating pressure/vacuum throughout the test.

C.2.4.2 Procedure

C.2.4.2.1 Pressurize/evacuate the system to be tested at nominal operating pressure/vacuum.

C.2.4.2.2 Using special gas test probes inserted into each terminal unit on all systems, check that all terminal units of the system under test are pressurized/evacuated, and correctly identified. No terminal units on other systems should be pressurized.

NOTE — During this test, all terminal units should be checked by means of special gas-specific probes to ensure that they correspond to the gas for which they are intended.

C.2.4.2.3 Observe the flow and pressure drop.

C.2.4.2.4 Depressurize/release vacuum from the system which has been tested.

C.2.4.2.5 Procedures C.2.4.2.1 to C.2.4.2.4 should be repeated for each service, ensuring all terminal units are tested — see C.2.4.2.2.

C.2.4.2.6 During the preceding tests, check the mechanical function of each terminal unit.

C.2.4.3 Test results

The pressure drop indicated at each terminal unit should be within the limit shown in table 1, at its specified flow.

Test gas should flow/vacuum should be created from each terminal unit on the system under test, but not from any terminal unit on any other system.

The mechanical action of each terminal unit should be satisfactory. The test probes should engage easily, lock firmly and disengage easily.

Identification should be on each terminal unit and be clearly visible and permanently attached.

C.2.5 Performance tests of the pipeline system

These tests should be carried out on one system at a time, but may be carried out in association with the tests in C.2.4.

C.2.5.1 General conditions

All zone isolation valves on all systems should be open.

Connect a supply of test gas at the source of the system to be tested, of sufficient capacity to meet the total design flow of the system.

C.2.5.2 Procedure

A sufficient number of special test probes should be inserted into selected terminal units throughout the system under test to provide a total flow equal to the total design flow of the system.

Pressurize/evacuate and maintain the system under test at operating pressure/vacuum.

Observe and record the system pressure at selected points.

Depressurize the system and repeat the test for each service.

C.2.5.3 Test results

The pressure drop at each of the points measured according to C.2.5.2 should not exceed the values given in table 1.

NOTE — If the pressure drop exceeds the values in table 1 at any point, it will mean either the pipes are too small for the total design flow, or a branch or a main pipe is partially blocked.

C.3 Tests of relief valves, safety valves and supply plant

C.3.1 Valve tests

These tests should preferably be carried out on one valve at a time.

C.3.1.1 General conditions

All relief valves and safety valves should be fitted.

All pressure-relief and -safety valves should be tested except type-tested valves.

C.3.1.2 Procedure

Isolate a section of pipework in which the valves to be tested are located.

Pressurize the pipework section with test gas using a source of suitable capacity. Gradually increase the pressure in the pipework.

Note the pressure at which the valves lift.

Reduce the pressure to normal operating pressure and note the pressure at which the valves close.

C.3.1.3 Test results

The pressures at which the relief valves operate should be in accordance with 5.1.8.

The pressures at which the safety valves operate should be in accordance with 5.1.9.

All valves should reseal at above maximum operating pressure.

C.3.2 Supply plant tests

C.3.2.1 General conditions

All supply plant should be installed and connected to normal and standby power supplies.

C.3.2.2 Procedure

All pipework joints in the plant installation should be tested for leakage at normal operating pressure/vacuum.

All functions and operating parameters of each item of supply plant should be tested in accordance with the specification of the manufacturer.

The plant should be shown to operate on the standby power supply.

C.3.2.3 Results

The test results should conform with the specification of the manufacturer or supplier of the system.

It should be confirmed that the specification of the manufacturer or supplier is in accordance with the design specification. Compressor plant should be pressure-tested for a period of 1 h during which minor leaks, detectable by bubbles, are acceptable.

C.4 Warning system tests

These tests should be carried out for one function at a time, and on one system at a time.

C.4.1 General conditions

All alarms should be installed and in operation.

C.4.2 Procedure

All alarm sensors should be shown to operate with an appropriate change in the local system condition (for example pressure, moisture content, liquid level, system change-over).

Note the settings at which alarm sensors switch on and off.

Observe all alarm functions, such as lights, auditory signal, resetting of the auditory signal and lamp test.

Check that the warning system will operate from the standby power source.

C.4.3 Results

All alarms listed in 6.2 and 6.3 should operate at the specified conditions.

All alarm functions should operate under normal and standby power sources.

C.5 Filling with specific gas for compressed medical gas systems

All systems may be filled with their specific gases at the same time.

C.5.1 General conditions

C.5.1.1 The previous tests should have been satisfactorily completed.

C.5.1.2 All sources of test gas should have been disconnected and removed.

C.5.1.3 Each pipeline system should be connected to its supply system.

C.5.1.4 Each pipeline system should be at atmospheric pressure.

C.5.2 Procedure

C.5.2.1 Open all zone valves.

C.5.2.2 Fill each pipeline system to the operating pressure with its specific gas from the supply source.

C.5.2.3 With the supply source closed, release the pressure in each system. It is advisable to vent oxygen and nitrous oxide outside the building.

C.5.2.4 Repeat C.5.2.2 and C.5.2.3 at least three times.

C.5.2.5 Open each terminal unit in turn at least once whilst the system is under pressure and connected to the supply source. This procedure should eliminate pockets of test gas.

C.5.2.6 Leave each system under operating pressure with the source connected.

C.6 Tests for cleanliness for compressed medical gas systems

C.6.1 Particulate matter

These tests should be carried out at all terminal units and may be combined with the filling procedure given in C.5.2.5.

C.6.1.1 General conditions

The pipeline system should be at operating pressure and connected to the supply source.

C.6.1.2 Procedure

Insert a full-bore probe into each terminal unit and hold a target of white paper or cloth at an appropriate distance from the terminal unit for 10 s.

C.6.1.3 Test results

There should be no particulate matter visible in good light to an operator with normal vision.

C.6.2 Contamination

These tests should be carried out at selected terminal units on each compressed gas pipeline.

C.6.2.1 General conditions

The pipeline system should be at operating pressure and connected to the supply source.

C.6.2.2 Procedure

Test each pipeline system at selected terminal units for oil contamination by the absence of odour or taste.

Test each pipeline system at selected terminal units for water droplets and water content.

Medical air pipelines using compressors as a source should be tested for carbon monoxide and carbon dioxide concentration.

C.6.2.3 Test results

There should be no taste or odour of oil.

NOTE — This is equivalent to an oil contamination of less than 0,5 mg/m^3.

There should be no water droplets and the dewpoint should not exceed + 5 °C at pipeline pressure.

The carbon monoxide level should not exceed 5 ppm (*V*/*V*).

The carbon dioxide level should not exceed 1 000 ppm (*V*/*V*).

C.7 Test for gas identity for compressed medical gas systems

All systems should preferably be tested at the same time.

C.7.1 General

All pipeline systems should have been filled with the specific gas at operating pressure according to the preceding clause.

During testing, do not connect the system to medical equipment.

C.7.2 Procedure

All terminals units should be tested with an oxygen concentration tester suitable for measuring the oxygen concentration of the specific gas.

C.7.3 Test results

The nominal oxygen concentration at the appropriate terminal units should be as given in table 6.

Table 6 — Test for gas identity — Nominal readings

Specific gas	Oxygen concentration % (*V*/*V*)
O_2	100
Air	21
N_2O	0
N_2	0
CO_2	0
He	0
Oxygen mixture	According to the mixture specification

Annex D

Recommended minimum requirements for the organization of maintenance

(This annex forms an integral part of the standard.)

D.1 General

A systematic approach to the maintenance of a non-flammable medical gas pipeline system is essential.

NOTE — This annex provides information that should be used when setting up a maintenance programme, but does not include actual maintenance tasks or frequencies.

D.2 Organization

D.2.1 Staff

Only qualified staff, familiar with the functioning of the equipment and with the proper practices for installation, testing and commissioning of medical gas pipelines should be appointed to supervise and to carry out maintenance work.

D.2.2 Maintenance programme

A maintenance programme should be established which includes specified maintenance tasks and their frequency.

This programme should include, as a minimum, the manufacturer's recommendations concerning service and maintenance instructions.

Particular attention should be paid to

a) performance of the system and its components;

b) leakage;

c) wear and tear;

d) contamination;

e) preventive maintenance.

A procedure should be instituted for the immediate reporting of defective or suspect equipment and its prompt repair or replacement.

D.2.3 Safe practices

The procedures for maintenance should include proper communications and documented control of the work.

If a maintenance operation involves shutting down parts of a pipeline system,

a) the shut-down should be fully coordinated with the clinical staff in the areas affected;

b) any valve(s) and terminal unit(s) affected should be marked to warn against their use.

If a maintenance operation involves breaking into a pipeline system, further action should be taken

a) to ensure safe working conditions;

b) to reduce contamination;

c) to purge the system to clear any contamination.

D.3 Documentation

A permanent documentation system should be set up which includes the documents as specified in 11.5 and this documentation system should be brought up to date when required, and be reviewed once a year.

The results of all tests and observations should be recorded in the documentation system.

D.4 Spare parts

The owner should ensure that spare parts as recommended in the list supplied by the installer (see 11.5.4) are readily available.

D.5 Retesting and recommissioning

Following any maintenance activity the appropriate tests in accordance with clause 12 should be carried out.

Annex E

Schematic representation of sources of supply systems

(This annex forms an integral part of the standard.)

Figures 6 to 13 are examples of supply systems which will provide safe and continuing service for patient care. Other system arrangements (designs) that meet the intent of the text of this International Standard and specific requirements of particular hospitals may be appropriate.

NOTES

1 The location of the emergency maintenance inlet, where shown, is optional.

2 In figures 6, 7, 8 and 11, duplexing of the line pressure regulators and safety/relief valves is shown; this duplexing is optional.

3 Other optional components on the figures are so marked.

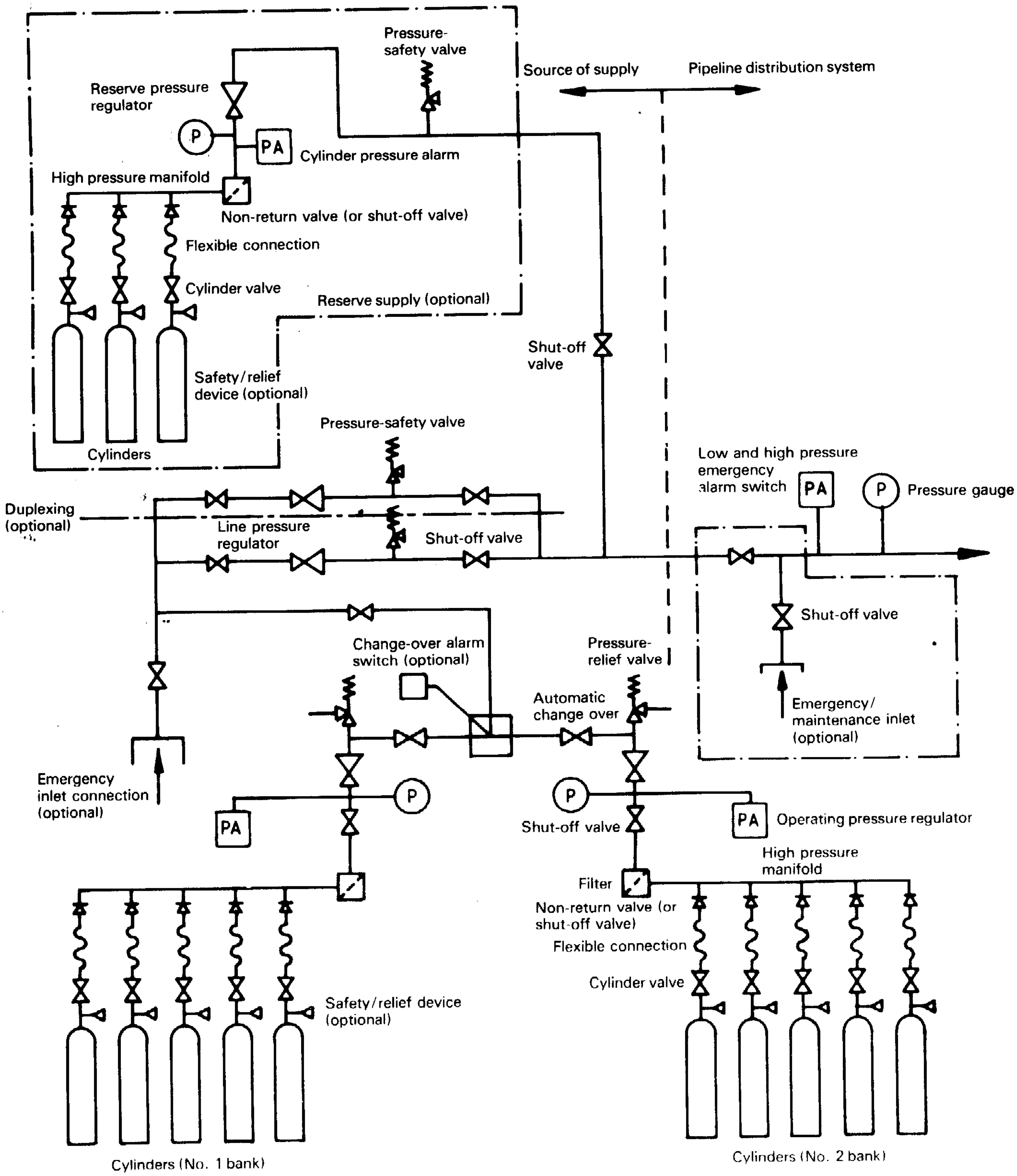


Figure 6 — Typical supply system with gas cylinders

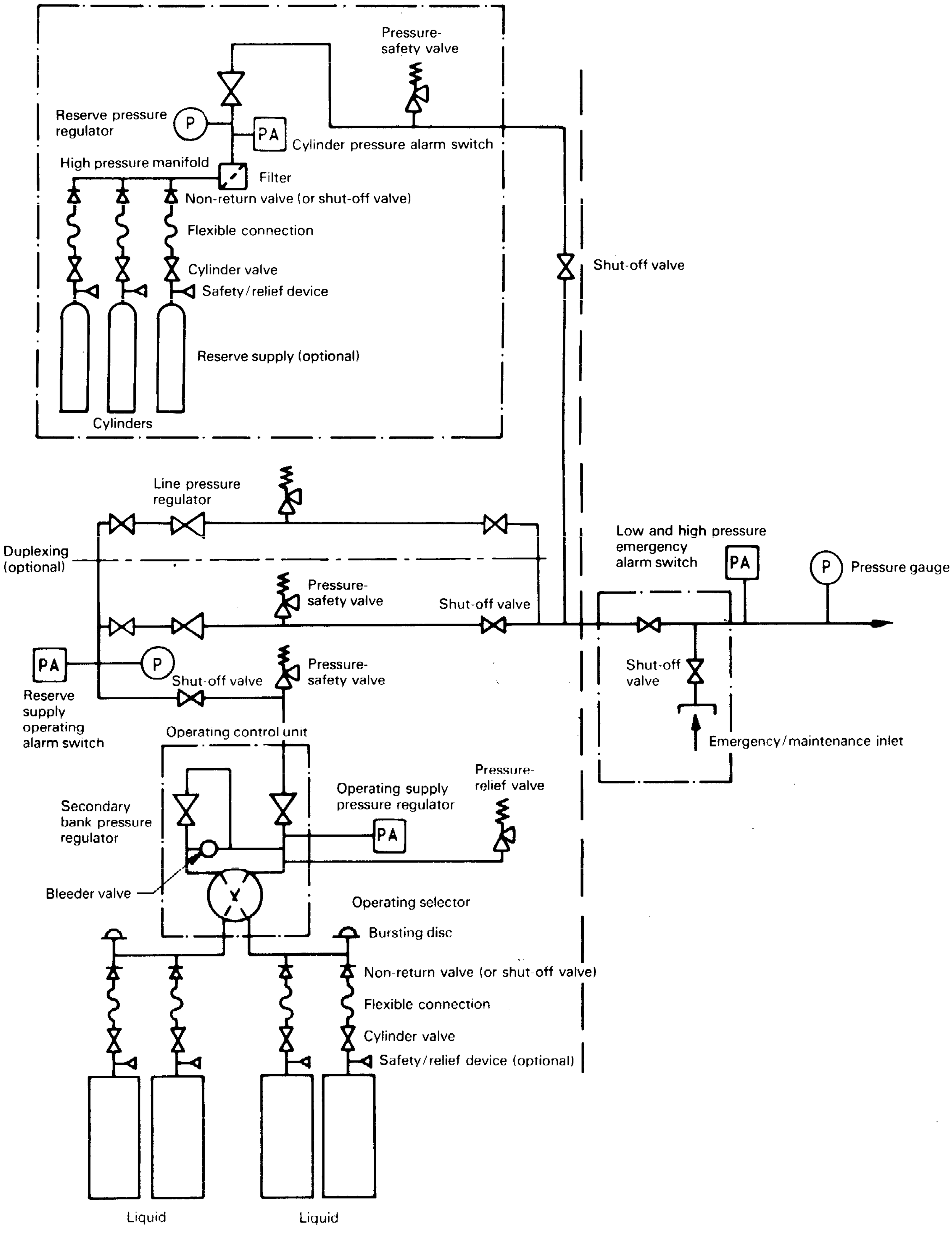


Figure 7 — Typical supply system with cryogenic cylinders

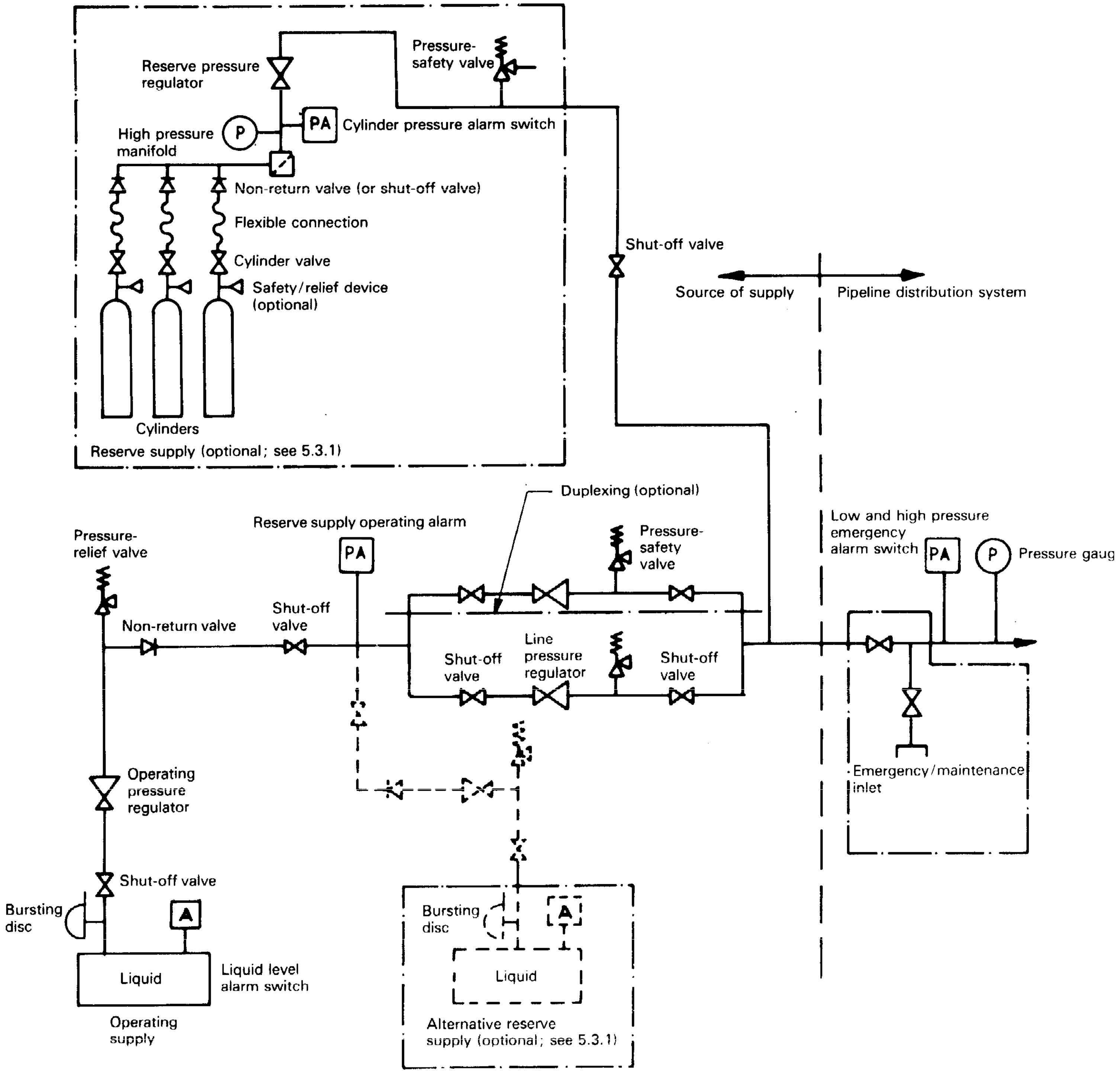


Figure 8 — Typical supply system with stationary cryogenic vessels

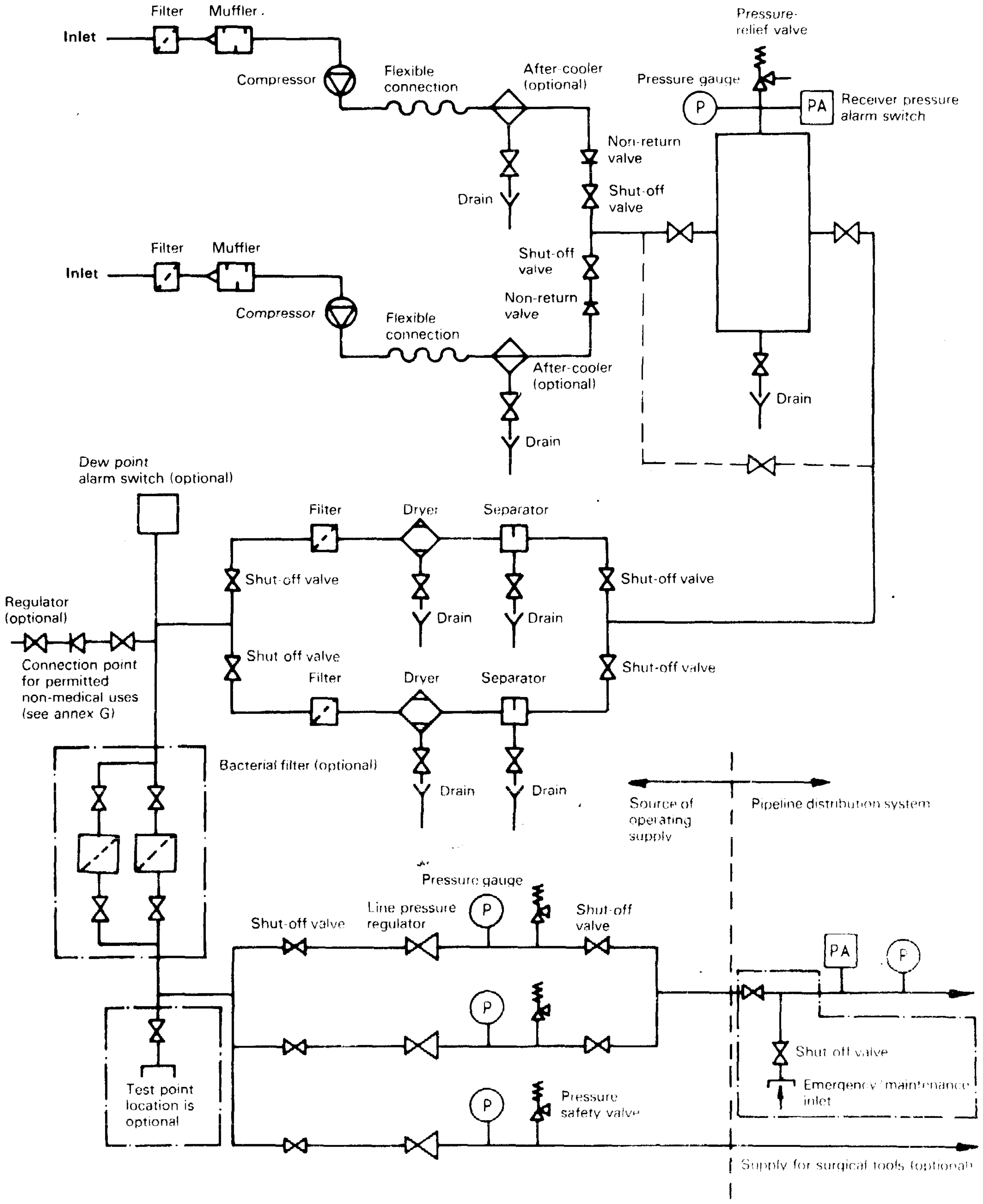


Figure 9 — Typical duplex medical air compressor system with receiver

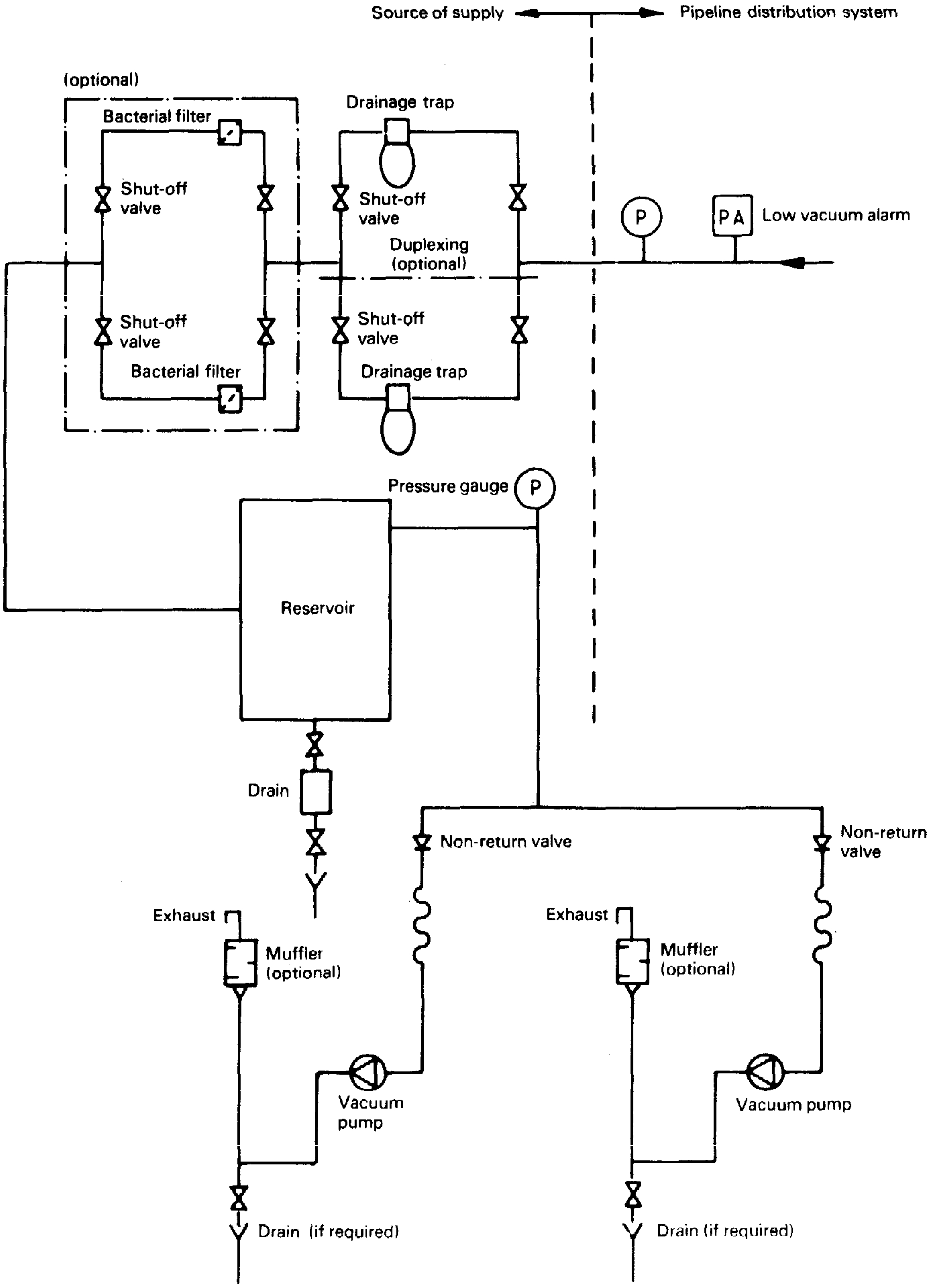


Figure 10 — Typical medical vacuum supply system with reservoir

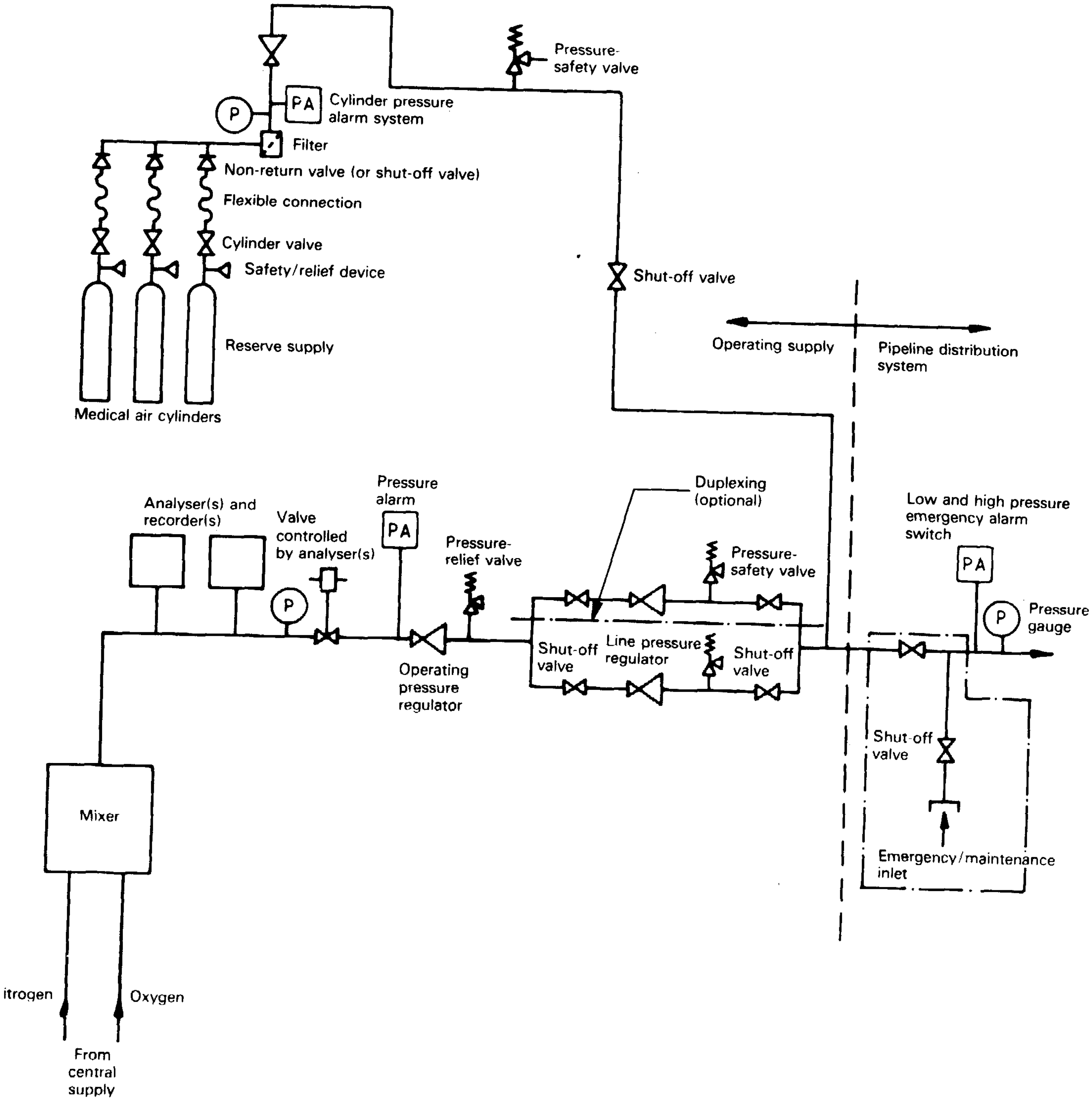


Figure 11 — Typical proportioning system of oxygen and nitrogen mixture

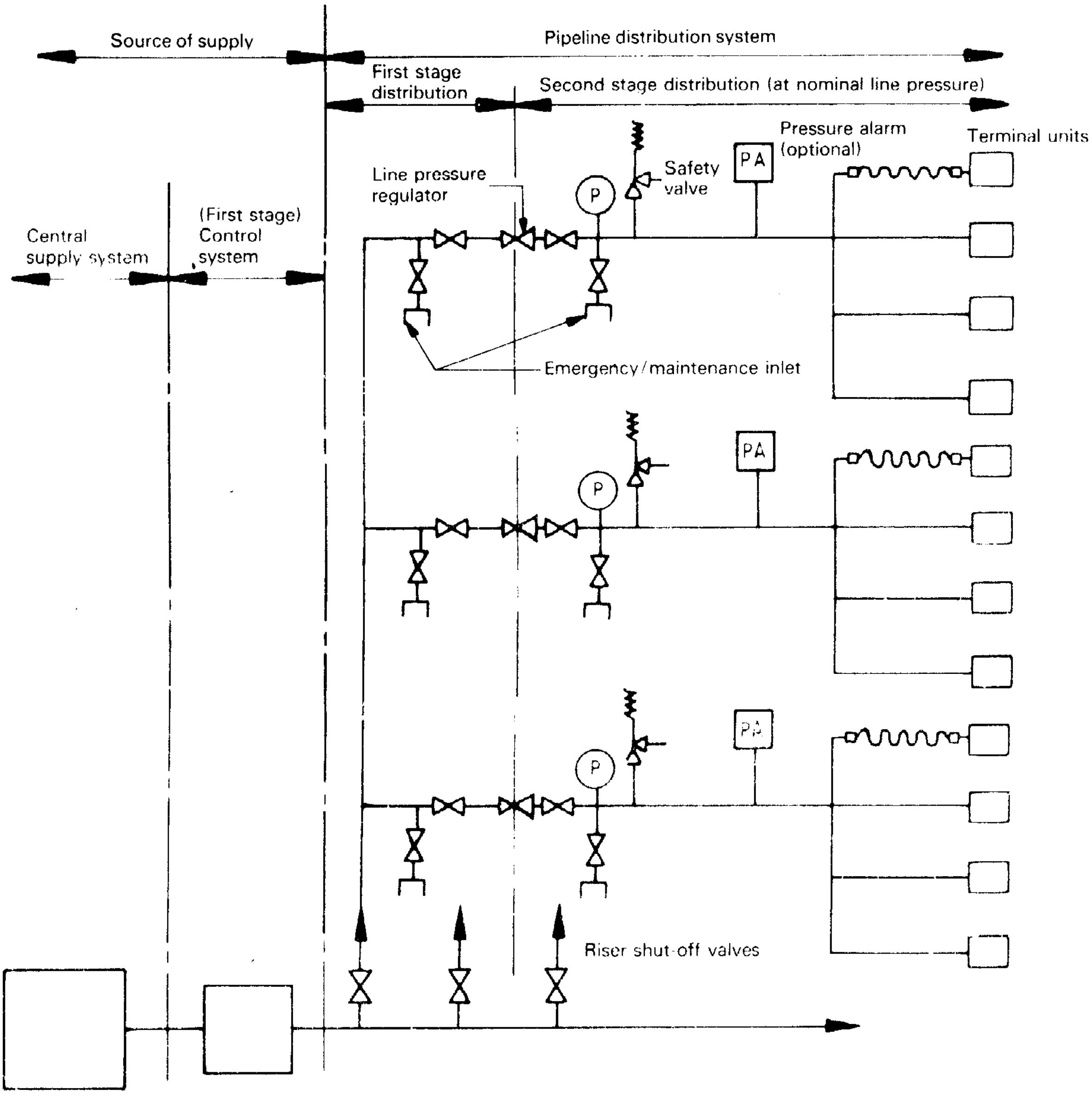
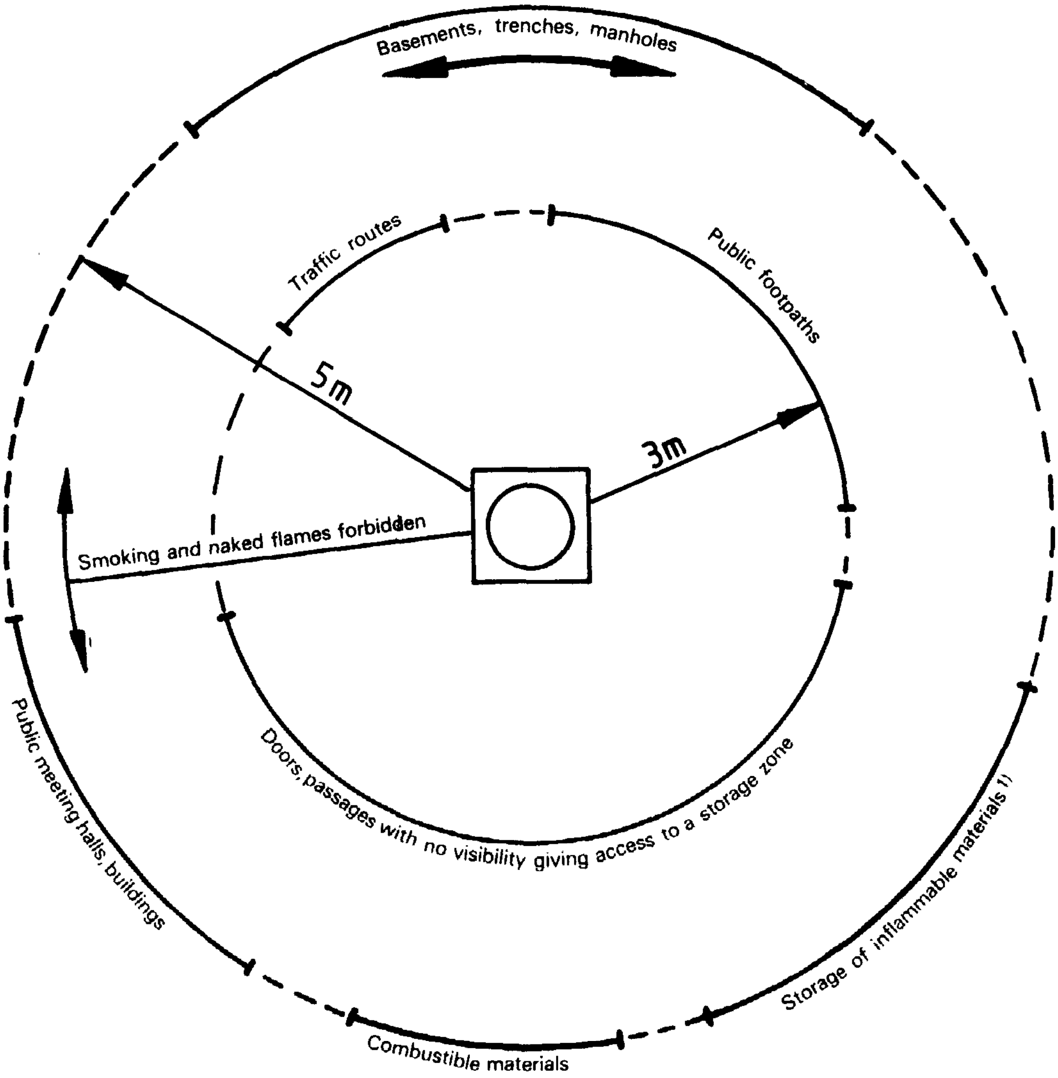

Source of supply
Pipeline distribution system
First stage distribution
Second stage distribution (at nominal line pressure)
Pressure alarm (optional)
Terminal units
Safety valve
PA
P
Line pressure regulator
(First stage) Control system
Central supply system
Emergency/maintenance inlet
Riser shut-off valves

Figure 12 – Typical system with control equipment within pipeline distribution system (double-stage pressure distribution system)


Basements, trenches, manholes
Traffic routes
Public footpaths
5 m
3 m
Smoking and naked flames forbidden
Doors, passages with no visibility giving access to a storage zone
Public meeting halls, buildings
Storage of inflammable materials 1)
Combustible materials

1) Except where a separate firebreak wall exists with a minimum height of 2,5 m.

Figure 13 — Recommended minimum distances for the siting of stationary cryogenic oxygen vessels

Annex F

Recommendations for emergency procedures

(This annex forms an integral part of the standard.)

F.1 General

F.1.1 Emergencies can arise which may result in the sudden cessation of the gas supply to one or more clinical areas.

Should such failures occur, it is vital that procedures have been set up which can ensure immediate action on

- communication of the problem to those persons and areas affected;
- conservation of supplies;
- remedial actions.

F.1.2 National or local regulations relating for fire precautions should be complied with.

F.2 Communication

F.2.1 Communication procedures should be set up to ensure that any emergency arising is notified immediately to all clinical areas likely to be affected and to all staff involved in the maintenance of gas supplies and in remedial actions.

F.2.2 Such communication should include

- the nature of the emergency;
- details of the gas conservation procedures to be applied;
- likely duration of the emergency;
- remedial actions to be taken.

F.2.3 Experienced persons should be nominated in each area to coordinate and communicate actions.

F.3 Conservation of supplies

F.3.1 On receiving an emergency notification, the coordinator in each clinical area should reduce the use of gas from the pipeline system(s) involved to the level required and bring into use their own reserves.

F.3.2 The staff responsible should check on reserves available and bring into use as necessary, plant and cylinders on reserve manifolds, emergency pipeline inlets, or at points of use.

F.3.3 If necessary, additional supplies of gas should be ordered from suppliers or from other hospitals to meet the expected duration of the emergency.

F.4 Remedial actions

F.4.1 The cause of the emergency failure of supply should be investigated immediately and action initiated to remedy the fault or damage.

F.4.2 Such investigations may show that other areas of the hospital, not initially affected, may need to be isolated to carry out repairs. In this case, communication and conservation procedures should be instituted in these areas before shutting off the gas supply to another system or area.

F.4.3 Remedial work should be carried out under an effective method of control, see clause 0.

F.5 Training

F.5.1 The staff responsible should be properly trained in the use of medical gases and pipeline systems and be fully familiar with their hospital pipeline layout and the location of all zone isolation valves.

F.5.2 Emergency procedures should be initiated at least twice a year as an exercise, and any problem or re-training action noted and followed up.

F.5.3 Actual emergency situations should be evaluated and appropriate action taken to improve procedures and training.

F.6 Nominated staff

Persons should be specifically nominated to attend, operate and maintain plant. They should be appropriately trained and qualified in the handling of cylinders and gas supply plants.

F.7 Reserve supplies

F.7.1 It is recommended that gas reserves in cylinders not normally connected to a source of supply are held in addition to reserves connected to a source of supply. The capacity of such unconnected reserves should be calculated to take into account the normal daily usage of the gas, the normal supply arrangements and the emergency procedures which will be taken in the event of a plant or gas supply failure.

F.7.2 Sufficient cylinders equal to the capacity of one manifold bank may be held in each manifold room. Additional cylinders may be held in an adjacent cylinder store.

F.7.3 Critical care areas may require their own cylinder reserves to minimize any delay in maintaining gas supplies in an emergency (see 5.1.3). If cylinders with attached regulators are used for this purpose, the regulator outlet should be gas-specific for connection to a low-pressure flexible connecting assembly (see 3.22).

F.8 Safety

F.8.1 Suitable handling facilities (e.g. purpose-designed trolleys) should be provided for the movement of cylinders.

F.8.2 Cylinder storage areas should be well ventilated and the cylinders should be stored in accordance with the supplier's recommendations. Full and empty cylinders should be segregated and the respective storage areas should be labelled.

F.8.3 Access to cylinder manifold rooms and storage areas should be level and kept clear, in particular emergency exits from these rooms and areas should be kept free of obstructions at all times. Emergency exits should lead into the open air or other safe location.

Annex G

Requirements to be complied with when extending a compressed air system to applications not directly related to patient care

(This annex forms an integral part of the standard.)

G.1 Arrangements shall be made to prevent back flow of air, preferably by operating the extension pipeline at a lower pressure than that in the line for patient care use.

G.2 An alarm system shall operate if the pressure in the extension pipeline exceeds the nominal operating pressure of the system used for patient care.

G.3 The maximum flow into the extension shall be limited to the design requirements.

G.4 The extension shall be connected to the main system at the source as shown in figure 9.

NOTE — In addition to the above requirements, arrangements should be made for the maintenance of the extension as part of the total medical compressed air system.

Annex H

Oxygen concentrator [pressure swing adsorber (PSA)]

(This annex does not form an integral part of the standard.)

H.1 General

The development of PSA plant has not yet been completed. This annex therefore is not comprehensive and is only provided to give preliminary guidance on the type of equipment and safety precautions envisaged as a basis for future development (see note 2 in 5.4).

H.2 Description

A PSA plant is designed to supply a hospital pipeline system and comprises compressor(s), as appropriate, or uses a separate medical compressed air source, nitrogen adsorber unit(s), reservoir(s) and associated equipment necessary to supply clean, dry, oil-free oxygen mixture of concentration not less than 90 % (V/V), generated from atmospheric air. The balance is mainly argon and nitrogen. The system should include oxygen analyser(s), recorder and a reserve supply (see 5.4).

H.3 Requirements

H.3.1 A PSA plant should be of such a capacity that the average calculated demand for the pipeline system can be continuously supplied. The PSA plant should include two or more compressors or utilize medical air from a pipeline.

H.3.2 The ambient air inlet for a PSA plant utilizing compressors should be located in a position where there is minimal contamination from all internal combustion engine exhausts, flues, vacuum system discharges, extract ventilation discharges, etc.

H.3.3 Compressor(s) may be of any type provided that they are capable of meeting the operational requirements of the system.

H.3.4 Any receiver(s) associated with the plant should be designed, manufactured and tested in accordance with the current national pressure vessels codes for unfired pressure vessels.

H.3.5 The plant should be provided with filters necessary to ensure that product gas is free of contaminants.

H.3.6 The plant should include pressure regulators complete with safety valves and shut-off valves, in parallel for maintenance purposes.

H.3.7 A PSA plant should also include a reserve supply which should be permanently connected and which should operate automatically if the oxygen concentration falls below the minimum permitted value or if the supply fails.

H.3.8 The reserve supply should have the designed flow capacity of the PSA plant. The volumetric capacity of the reserve should be specified, taking into account the average demand and availability of the gas concerned.

H.3.9 The oxygen concentration should be analysed and monitored continuously by at least one instrument and should be recorded. The analyser should be capable of independently and automatically isolating the PSA plant from the pipeline in the event of a malfunction.

H.3.10 All electrical wiring of the PSA plant and associated equipment should conform to the relevant IEC Publications. The electrical supply should be connected to both the normal and standby supplies.

H.3.11 The PSA plant should be installed in a well lit, ventilated and clean location with ample accessibility. The location should be provided with drainage facilities. Special precautions should be taken to ensure the removal of the vented gases from the area of the plant and its safe dispersal to the atmosphere. The plant should be located separately from other medical gas sources except air compressor units and vacuum plant.

NOTE — The A-weighted sound pressure level arising from the operation of PSA plant measured within the plant room will often exceed 85 dB. This level may be unacceptable in some situations and appropriate action should be taken. Any vibration in the plant should be reduced by the installation of flexible connections.

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